INDUSTRIAL
PRODUCTS
DIVISION

servo/riter® II

FLUSHMOUNT RECORDERS

TEXAS INSTRUMENTS
INCORPORATED
HOUSTON, TEXAS

servo/riter® II

FLUSHMOUNT RECORDERS

OPERATION AND MAINTENANCE MANUAL

PART NO. 185000-0006E

INDUSTRIAL
PRODUCTS
DIVISION

TEXAS INSTRUMENTS
INCORPORATED

P.O. BOX 66027 HOUSTON, TEXAS 77006

CABLE: TEXINS

Copyright 1969

By

Texas Instruments Incorporated

All Rights Reserved

PRINTED IN U.S.A.

The information and/or drawings set forth in this document and all rights in and to inventions disclosed herein and patents which might be granted thereon disclosing or employing the materials, methods, techniques or apparatus described herein are the exclusive property of Texas Instruments Incorporated.

No disclosure of the information or drawings shall be made to any other person or organization without the prior consent of Texas Instruments Incorporated.

TABLE OF CONTENTS

Section	Title	Page
1	GENERAL DESCRIPTION	
1.1	Scope of Manual	1-1
1.2	Specifications	1-2
1.3	Summary of Startup Procedure	1-2
2	INSTALLATION AND PRELIMINARY CHECKOUT	
2.1	Mounting the Equipment	2-1
2.2	External Connections	2-1
2.2.1	Rear Access	2-1
2.2.2	Front Access	2-1
2.2.3	Power Connections	2-4
2.2.4	Input Connections	2-6
2.2.5	Accessory Connections	2-7
2.3	Detailed Checkout Description	2-7
2.3.1	External Connections	2-7
2.3.2	Chart Paper	2-7
2.3.3	Power Switches	2-9
2.3.4	Chart Carriage	2-9
2.3.5	Deadband and Gain	2-9
2.3.6	Zero Control	2-9
2.3.7	Inking System	2-9
3	OPERATING INSTRUCTIONS	
3.1	Chart Loading	3-1
3.2	Inking	3-2
3.3	Chassis Handle and Slides	3-2
3.4	Adjustments of Controls	3-3
3.4.1	Power Switch	3-3
3.4.2	Gain Adjust	3-3
3.4.3	Gain Hi-Lo Switch	3-4
3.4.4	Zero Control	3-4
3.4.5	Damping Control	3-4
3.4.6	Calibrate Control	3-4
3.5	Changing Range Cards	3-5
3.6	Chart Carriage	3-7
3.6.1	Selection of Change Gears	3-7
3.6.2	Motors	3-7
3.6.3	Other Features	3-7
4	THEORY AND DEFINITIONS	
4.1	Null-Balance Recorder Theory	4-1
4.1.1	Damping	4-1
4.1.2	Filtering	4-2
4.1.3	Common-Mode Isolation	4-2
4.1.4	Theory of the servo/riter® and multi/riter* Recorders	4-3
4.2	Feedback	4-3
4.3	Filtering	4-4
4.4	Error Amplifier	4-5
4.5	Reference Power Supply Unit	4-7
4.6	Chart Carriage	4-9
4.7	Definitions	4-9
5	MAINTENANCE AND TROUBLESHOOTING	
5.1	Removal of Dust Cover	5-1
5.2	Troubleshooting Servo Measuring System	5-1
5.2.1	Recorder Pen Drives Against Stop	5-1
5.2.2	Dead Servomotor	5-2
5.2.3	Recorder Does Not Follow Signal	5-4
5.2.4	Recorder Follows Signal, But Motor Hums and Pen May Vibrate	5-4
5.2.5	Pen Does Not Stand Still With Constant Input Signal	5-5
5.3	Servicing the Amplifier and Input Board	5-5
5.3.1	Selected Components	5-9
5.3.2	Reference Voltage Unit	5-10
5.4	Chart Carriage	5-11
5.4.1	Removal of Chart Drive Sprocket	5-11
5.4.2	Shortening Drive Chain	5-11
5.4.3	Chart Carriage Drive Chain Cleaning	5-13
5.4.4	Chart Carriage Lubrication Points	5-13
5.5	Pen Drive Assembly	5-14
5.5.1	Pointer Removal	5-14
5.5.2	Pen Carriage Removal	5-14
5.5.3	Motor Pulley Assembly Removal	5-15
5.5.4	Servomotor Removal	5-15
5.5.5	Slidewire Removal	5-15
5.6	Cleaning Ink Pens	5-15
6	REPLACEABLE PARTS	

*Trademark of Texas Instruments Incorporated

LIST OF ILLUSTRATIONS

Figure	Title	Page
2-1	Outline and Mounting Dimensions (Sheet 1 of 2: Wide-Carriage Recorder)	2-2
2-1	Outline and Mounting Dimensions (Sheet 2 of 2: Narrow-Carriage Recorder)	2-3
2-2	External Connections (Wide Carriage Recorder Shown)	2-4
2-3	Power and Optional Accessory Wiring	2-5
2-4	Input Connection Summary	2-8
3-1	Chart Loading and Locations of Controls (Wide Carriage Recorder Shown)	3-1
3-2	Servomotor Drive (Wide Carriage Recorder Shown)	3-2
3-3	Input Board (Wide Carriage Recorder Shown)	3-5
3-4	Schematic, Millivolt Range Card	3-6
4-1	Simplified Recorder Diagram	4-1
4-2	Simplified Recorder Schematic	4-3
4-3	Schematic, Amplifier and Input	4-6
4-4	Power Supply Board Assembly	4-8
4-5	Schematic, Power Supply	4-8
5-1	Removing Connections	5-2
5-2	Location of Components	5-6
5-3	Amplifier Oscilloscope Patterns	5-8
5-4	Chain Drive	5-12
5-5	Schematic, Basic Chart Drive	5-12
5-6	Pen Carriage Removal	5-14
5-7	Cabling Instructions (Sheet 1 of 3: Wide-Carriage Recorder, One and Two Channel)	5-16
5-7	Cabling Instructions (Sheet 2 of 3: Wide-Carriage Recorder, Multichannel)	5-17
5-7	Cabling Instructions (Sheet 3 of 3: Narrow-Carriage Recorder)	5-17

LIST OF TABLES

Table	Title	Page
1-1	Recorder Described by This Manual	1-1
3-1	Change Gear Selection, Standard (Inch) Speeds	3-8
3-2	Change Gear Selection, Metric Speeds	3-9
5-1	DC Voltages With Small Error, Gain Potentiometer Counterclockwise	5-7
5-2	Selected Components	5-9
5-3	Voltage Chart	5-10

SECTION 1

GENERAL DESCRIPTION

1.1 SCOPE OF MANUAL

This manual contains operating and service instructions for the servo/riter® II Potentiometric Recorders manufactured by Texas Instruments Incorporated, Houston, Texas.

Texas Instruments supplies recording instruments designed to customer requirements and it would be impractical to issue a manual custom-designed to each instrument. This instruction manual covers standard equipment, and blueline drawings further describe a recorder where circuit or major assembly changes have been made to meet specific customer requirements. Table 1-1 provides the serial number and information on the recorder this particular manual describes.

The servo/riter® recorder is a self-balancing potentiometric strip chart recorder, for accurate recording of dc signals. The signal input leads are floating above ground and the circuit makes use of a guard shield to

TABLE 1-1

RECORDER DESCRIBED BY THIS MANUAL

MODEL _____ SERIAL NO. _____

1. CHANNEL	A	B	C	D	E	F
Span						
Speed-Seconds						
Attenuator						
Zero						
Pen Lifter						
Control Contacts						
Retransmit Potentiometer						

2. CHART DRIVE

3. ACCESSORIES

Left Marker ☐ Lighting ☐

Right Marker ☐ Tilt Out Platen ☐

Door ☐ Lock ☐ Chart Supply Indicator ☐

4. POWER _____ V _____ cps

5. SPECIAL PRODUCT DRAWING NO. _____

accurately record signals that have ac longitudinal and dc common-mode interference. The recorder uses a low-pass input filter to provide transverse interference rejection.

The electronics is solid state, including a photoconductive chopper. A zener reference unit is standard on all servo/riter® II recorders. The portable model is available in one or two channels. The flushmount recorder is designed to fit a standard 19-inch rack without special adapters and is available in one to six channels with many options and accessories. These are listed in the servo/riter® brochure.

Primary applications occur with manufacturers of instruments or end users which require a dc recorder readout either built-in or as a separate accessory. Such instruments, used for research laboratory, engineering test, clinical operations and industrial processes, include the following typical examples:

Gas chromatographs

UV and IR spectrophotometers

Radiation control meter

Mass spectrometers

Respiration analyzers

X-ray spectrometers and diffractometers

Electrobalances

Precision voltmeters

Line and frequency standards

Polaragraphs

Polarimeters

Cardiac densitometers

Environmental test stands

Performance test stands

Life test stands

Received signal and noise level

Magnetic intensity meters

Meteorological instruments

1.2 SPECIFICATIONS

Electrical and mechanical specifications are listed in Appendix A.

1.3 SUMMARY OF STARTUP PROCEDURE

Placing the servo/riter® II into operation requires these simple steps.

a. Physical mounting of recorder (Paragraph 2.1)

b. Connecting power (Paragraph 2.2.3)

c. Applying signals (Paragraph 2.2.4)

d. Connecting accessories (Paragraph 2.2.5)

e. Installing chart paper (Paragraph 3.1)

f. Filling and priming inkwells (Paragraph 3.2)

g. Using operational controls (Paragraph 3.4)

SECTION 2

INSTALLATION AND PRELIMINARY CHECKOUT

2.1 MOUNTING THE EQUIPMENT

Figure 2-1 shows dimensions for panel mounting of wide- and narrow-carriage recorders.* To mount the recorder in a panel mounting surface:

a. Place recorder on floor or bench to provide support under the chassis when it is pulled out.

b. Open the back panel and lay it back on its hinge.

c. Lift up on the chassis latch handle and pull out the chassis until it stops.

d. Lift up the back panel and rotate 90°. Place it inside the case in back of the chassis.

e. Release the slide stops, pull out the chassis and attached back panel through the front of the case. The empty case may now easily be placed in a rack or panel and attached with eight 10-32 x 3/8" binding-head screws.

f. After the case is secured, reverse the preceding instructions to install the chassis. Check that the Z-fold cable remains clear of the chassis as the chassis is slid back into the case.

The recorder is now ready for power connection.

2.2 EXTERNAL CONNECTIONS

All external connections are made inside the rear panel as shown in Figure 2-2. Working access to these connections is convenient from the front or rear of the recorder case.

2.2.1 Rear Access

For rear access remove the four screws holding the rear panel in place and pivot the panel about its bottom edge. The catch at the bottom edge of the panel holds the rear panel in a horizontal position to form a shelf.

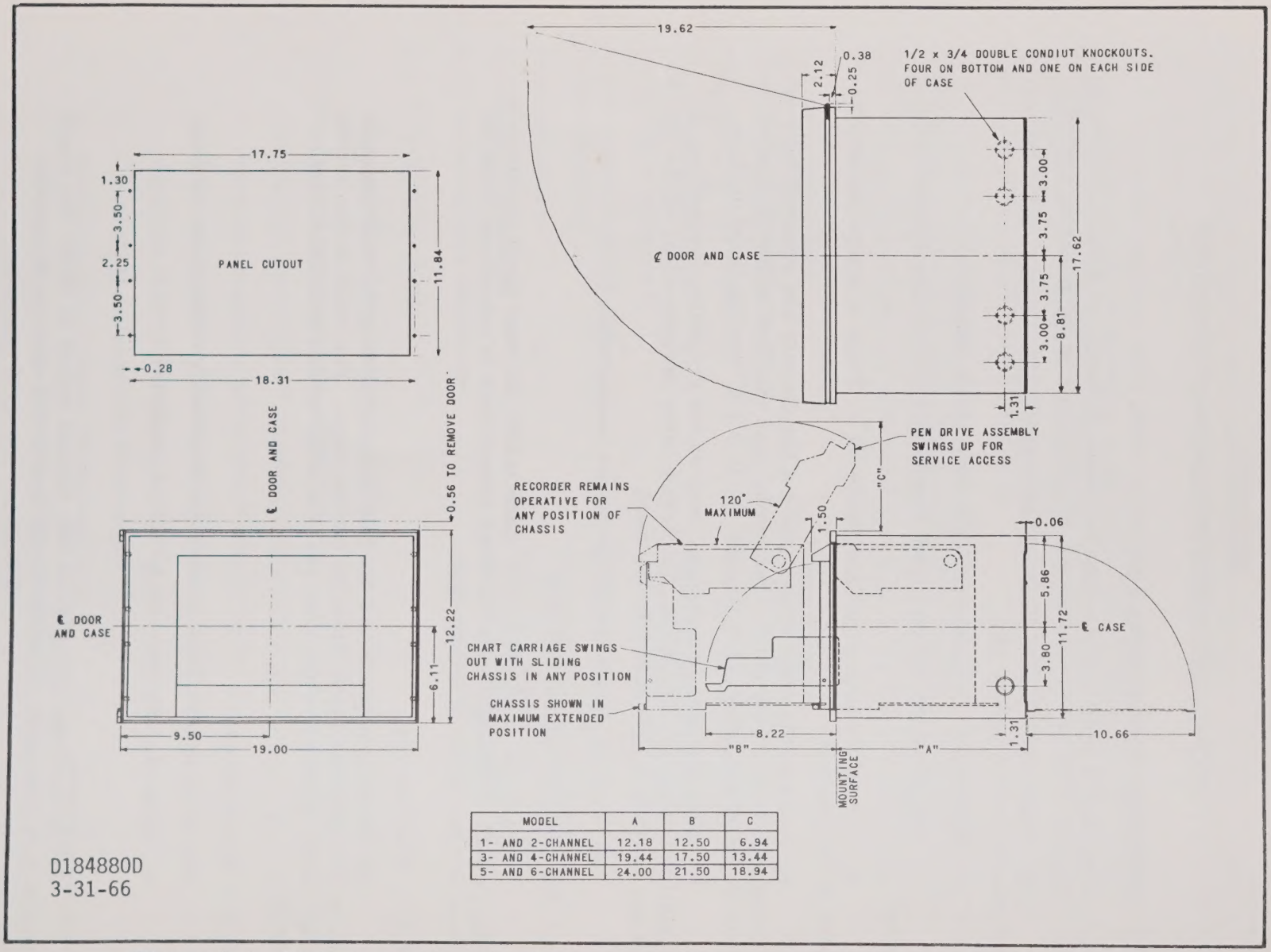
2.2.2 Front Access

For front access first remove the recorder chassis from its case.

a. Slide the recorder out as far as possible.

---

*Wide carriage recorder in this manual refers to either the single 9-3/4-inch wide-grid recorder or the dual 4-1/2-inch-grid recorder. Narrow carriage refers to the 6-inch narrow-grid recorder.



MODEL	A	B	C
1- AND 2-CHANNEL	12.18	12.50	6.94
3- AND 4-CHANNEL	19.44	17.50	13.44
5- AND 6-CHANNEL	24.00	21.50	18.94

Figure 2-1. Outline and Mounting Dimensions (Sheet 1 of 2: Wide-Carriage Recorder)

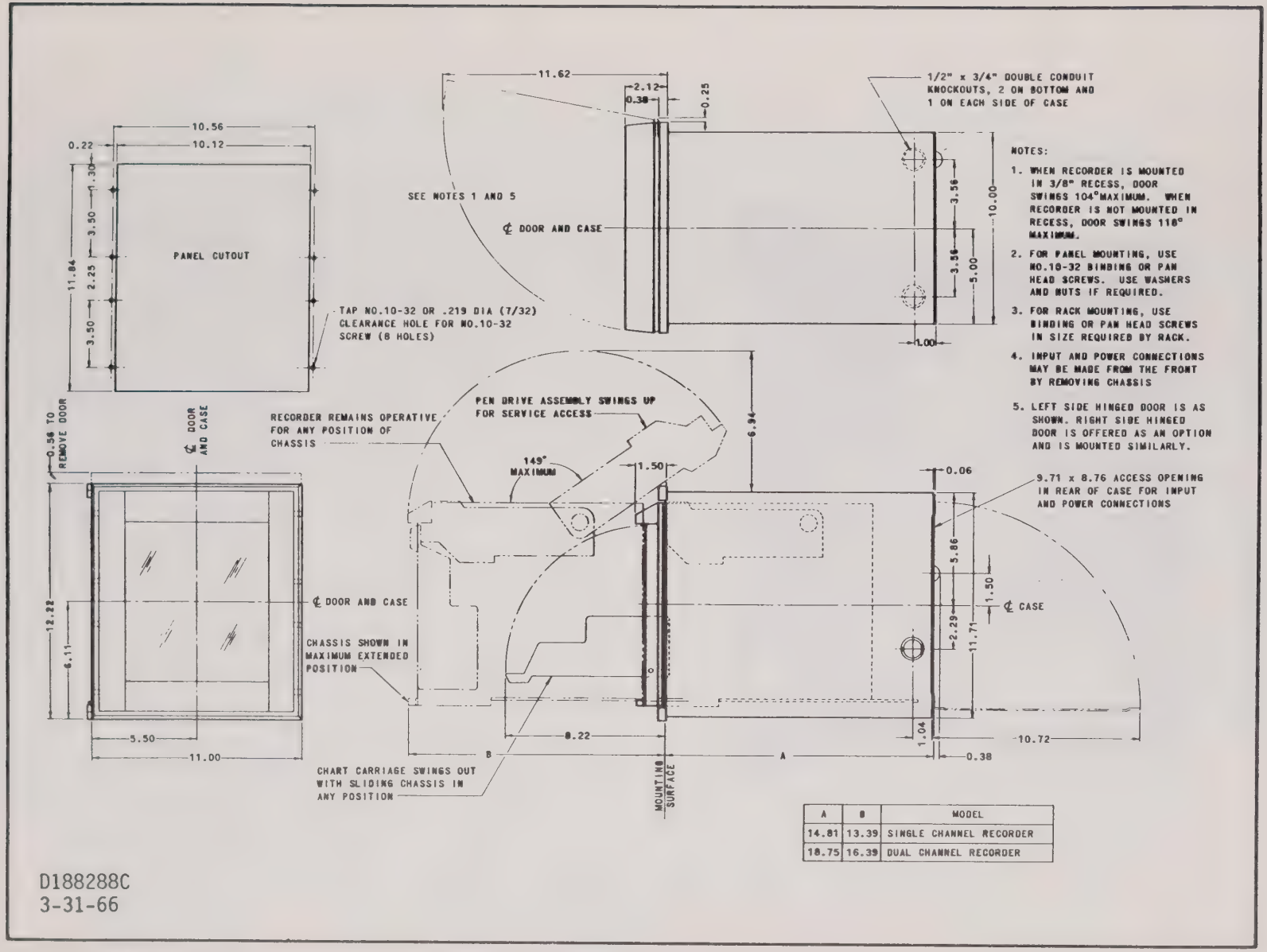


Figure 2-1. Outline and Mounting Dimensions (Sheet 2 of 2: Narrow-Carriage Recorder)

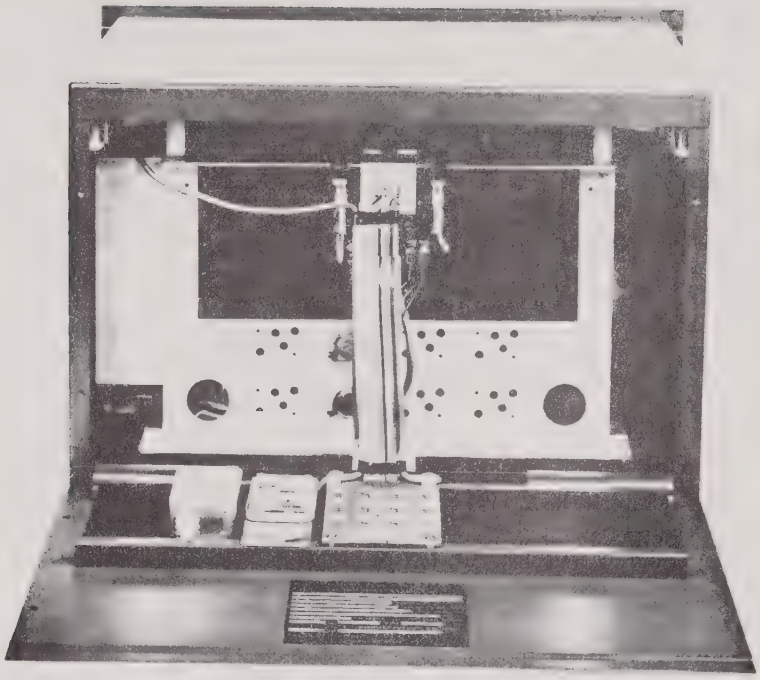


Figure 2-2. External Connections (Wide Carriage Recorder Shown)

b. Loosen the screw at the back of the chassis between the two fuses.

c. Push the flat cable connector out.

d. Remove the cover to the input board and disconnect the grey shielded input cable from the pins. This breaks all electrical connections between the recorder and the recorder case.

e. Lift up on the recorder chassis and pull it completely out of the case.

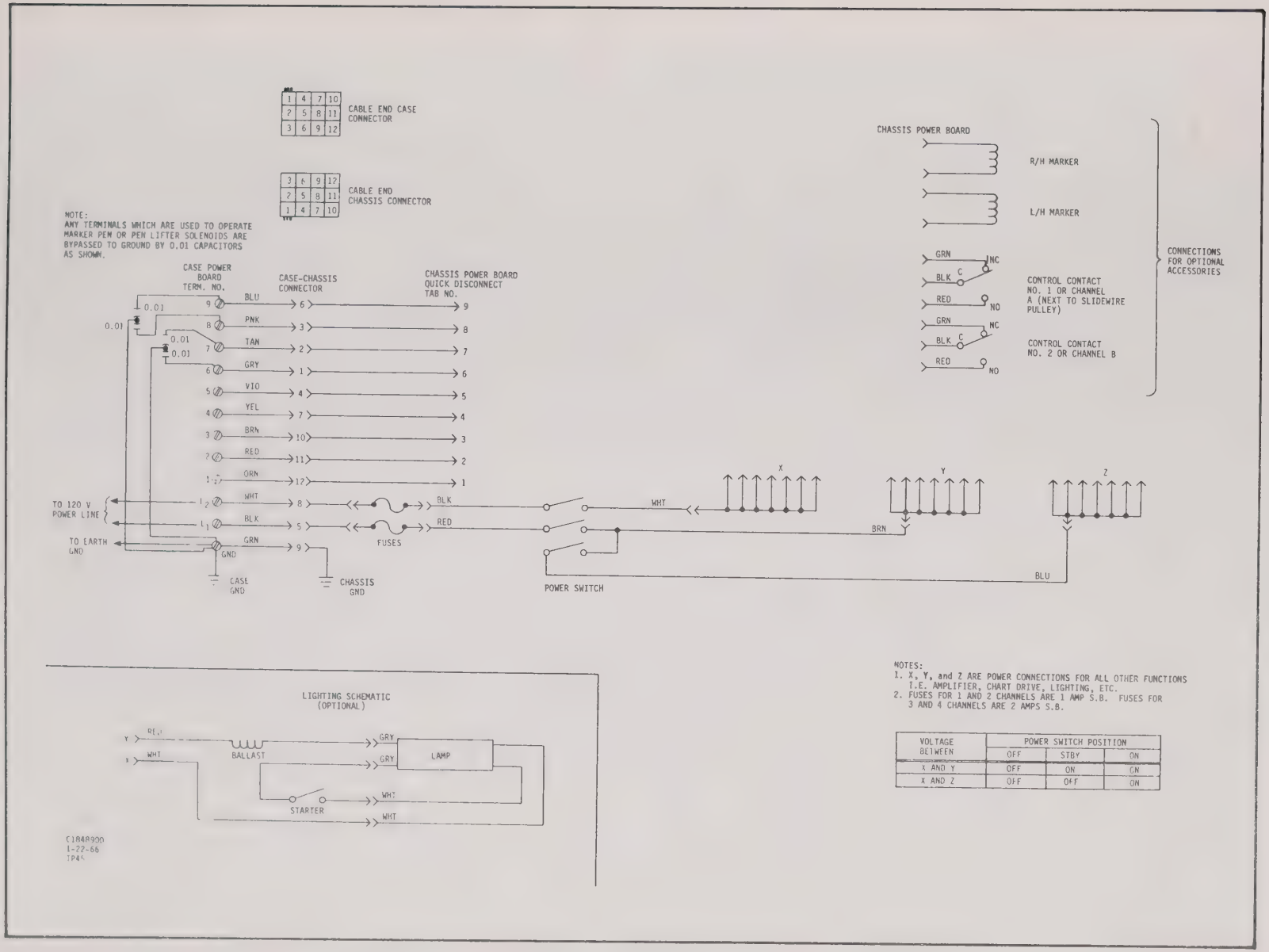
It is now possible to reach the connections on the back cover through the front of the case.

2.2.3 Power Connections

Figure 2-2 shows the power and accessory terminal board provided inside the rear panel. Figure 2-3 shows power and accessory wiring terminal connections. Three terminals are provided for the power connections, L1 and L2 for power, and GND for ground connection. Knockout plugs are provided for 1/2-inch and 3/4-inch conduit or for a clamping bushing if a standard line cord is to be used.

WARNING

A good ground connection is essential for operator safety and for elimination of electrical interference.



VOLTAGE BETWEEN	POWER SWITCH POSITION		
	OFF	STBY	ON
X AND Y	OFF	ON	ON
X AND Z	OFF	OFF	ON

Figure 2-3. Power and Optional Accessory Wiring

2.2.4 Input Connections

An insulated and shielded cable such as Belden 8771 (TI Part 230252-0005) or equivalent is recommended for recorder connections. If this type of cable is not available, twist the signal (positive and negative) leads for best results. The leads should be kept as short as possible to reduce interference and carefully routed to avoid obvious sources of interference such as power lines and magnetic fields.

The correct connection depends on the characteristics of the signal source being monitored - for example, whether the source is grounded or floating, the amount of impedance to ground, etc; therefore, some knowledge of the source is required.

Additional precautions are necessary when operating the recorder with a completely floating input circuit. Such a situation is subject to signal source leakage currents and high common-mode interference. Care should be taken that input connections reject most recorder interference.

The recorder input connections are in the small aluminum box on the terminal board mounted on the inside rear of the recorder outer case. Terminals are marked INPUT +, INPUT –, and GUARD. The guard terminal connects to the aluminum box covers and to the input cable shield. Through this shield the guard terminal is also connected to the shield over the input section and measuring circuits of the servoamplifier.

For ground connection, a jumper wire is supplied between guard terminal and the input box mounting screw. If a ground connection is not required, the jumper wire should be disconnected from the guard terminal and not the ground screw.

In the majority of applications the negative side of the input is connected to the guard. The shield on the signal input cable should also be connected to the guard terminal. In some cases, when the positive lead has a lower impedance to the source of ac longitudinal stray voltage than the negative lead, better interference rejection is obtained by connecting the guard to the positive terminal.

Do not ground the guard or either of the signal leads at the recorder if the signal source has a ground. Having more than one ground is one of the most common sources of noise in low-level measuring systems. This is especially true when the signal source and the measuring system lack a common ground. However, if the signal source is floating and has no other connection to ground, such as a thermocouple in air, connect the guard and the negative input terminal to ground at the recorder.

Figure 2-4 is a summary of the best input connections for various sources.

NOTE

The guard is always connected to either the + or – input terminal, depending on which terminal is closest in resistance to the common-mode interference voltage source.

2.2.5 Accessory Connections

The nine spare terminals on the power terminal board inside the rear panel connect accessories such as markers, control contacts, pen lifters, etc. If the recorder has accessories requiring more than nine terminals, a second terminal board is added for an additional twelve terminals. The appropriate appendix describes connections of these accessories.

2.3 DETAILED CHECKOUT DESCRIPTION

The following preliminary checkout will make the operator generally familiar with the recorder and will help determine if there has been any hidden damage during shipment. The steps listed below are detailed in this section.

a. Open the rear cover and connect the power and input wiring as has been described.

b. Load the chart roll into the chart carriage described in Section 3.

c. Turn the power switch on (Paragraph 2.3.3).

d. Check the chart carriage operation (Paragraph 2.3.4).

e. Check the deadband of each channel and adjust the gain, if necessary (Paragraph 2.3.5).

f. Check operation of the zero control (Paragraph 2.3.6).

2.3.1 External Connections

Open the rear cover and connect the signal and power wiring. The operation of the recorder cannot be checked properly if an erratic signal is connected to it. Sometimes it is better to substitute a dummy input circuit while setting up gain for best deadband: on millivolt input types, for example, short and ground the input terminals. See the preceding section on input connections for details.

2.3.2 Chart Paper

Load the chart paper into the chart carriage, but do not ink the pen unless the recorder is to be used within a short time. This way the inkwells will not have to be emptied and cleaned if the recorder has been broken, or if there is to be several days between checkout and use. Section 3 gives details on chart loading.

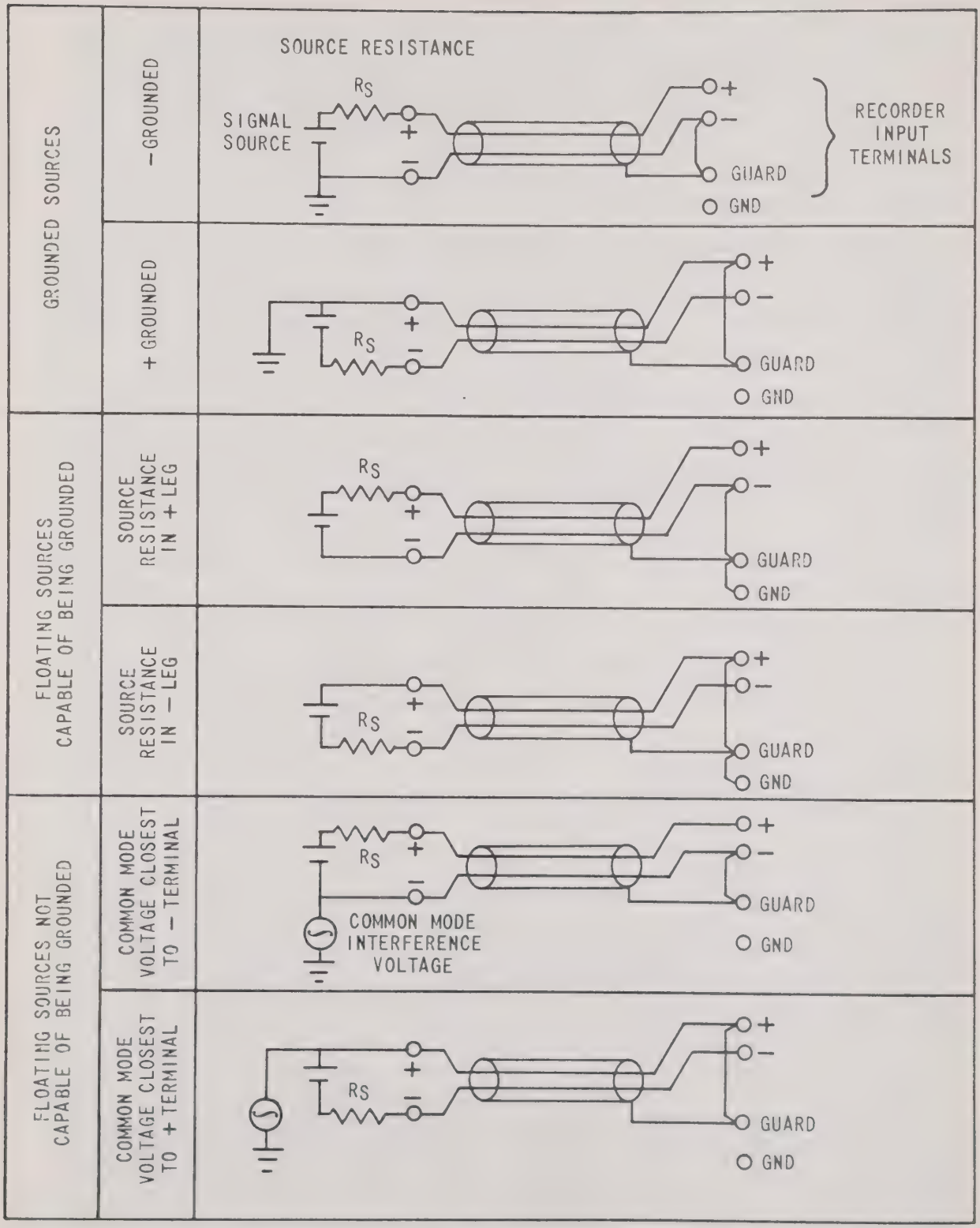


Figure 2-5. Input Connection Summary

2.3.3 Power Switches

Turn the power switch ON. All power switches have at least two other positions, OFF and STANDBY. In STANDBY there is power to all parts of the recorder except the motors. In the ON position power is supplied to all parts of the recorder including the motors. When the power switch is first turned to STANDBY or ON, it takes about 5 seconds for the amplifier power supplies to come up to full operating voltage.

2.3.4 Chart Carriage

Check the chart carriage operation. When the power switch is ON, both the top drive roller and the takeup spool are driven by the chart drive motor. The paper sprocket holes should match the sprocket teeth. If they do not match, check for damage to the rollers and chart roll suspension points.

2.3.5 Deadband and Gain

Check the deadband of each channel and adjust the gain if necessary.

To check deadband:

a. Pull the recorder chassis out (on its slides).

b. Use the pulley on the servomotor shaft to move the pen pointer one way and then the other on its scale. Allow the pointer to come to rest slowly each time and note the rest position.

c. The deadband of this channel is the difference between these two rest positions in percent of full span. (See Paragraph 3.4.2 for detailed description).

d. Deadband may be decreased by advancing the gain control.

2.3.6 Zero Control

Check the zero control operation. Use a screwdriver to turn the ZERO potentiometer on the amplifier. If the gain has been set right, the pen pointer should follow closely. Be careful not to turn the CAL potentiometer by mistake.

2.3.7 Inking System

Fill the ink reservoirs and prime each pen. See Section 3 for complete details.

SECTION 3

OPERATING INSTRUCTIONS

3.1 CHART LOADING (Figure 3-1)

Remove the takeup roll containing the old chart from the recorder. This is done by pressing the spring latches outward to release and pulling the roll forward. If the roll is full, lift up on the handle-latch bar and pull the chassis out far enough to reach underneath and behind the paper roll.

Pull out the flanged hubs from the old chart and the recorder is ready for a new roll of chart paper. To reload:

a. Insert the flanged hubs into ends of a new chart roll. To prevent tapering the roll, insert both hubs lightly and then push tight with both hands.

b. Swing the chart carriage open by pulling on grips at each side of the top of the chart carriage.

c. Remove the empty supply spool and hubs by releasing the spring latches.

d. Insert the new chart roll with flanges into supply position with the round sprocket holes of the chart to the left.

e. Pull out about 14 inches of chart and wrap around the drive sprocket, engaging the teeth in the chart holes.

f. Close the chart carriage.

g. Tape the end of the chart to the chart core from the old supply roll, and insert into takeup position at the bottom of the chart carriage.

h. Roll the takeup hub flanges until the chart is tight.

3.2 INKING

a. Using the ink syringe supplied with the recorder, slowly fill the inkwell about 7/8 full. Do not seal the entrance hole with the rubber tip of the syringe and the inkwell will fill without bubbling.

b. To prime the pen, press the rubber tip of the ink syringe snugly against the entrance hole and apply enough pressure to start ink flowing. Remove the syringe from the inkwell opening before releasing the bulb pressure to avoid suction of ink back into the inkwell. Blot up excess ink from the chart with a piece of tissue.

3.3 CHASSIS HANDLE AND SLIDES

The chassis is mounted in the case on extension slides and is latched in by a combination handle-latch bar. To release the latch, pull up on the bar at the lower front edge of the chassis. The chassis now can be pulled straight out to the stops. On the wide-carriage recorder, a release is

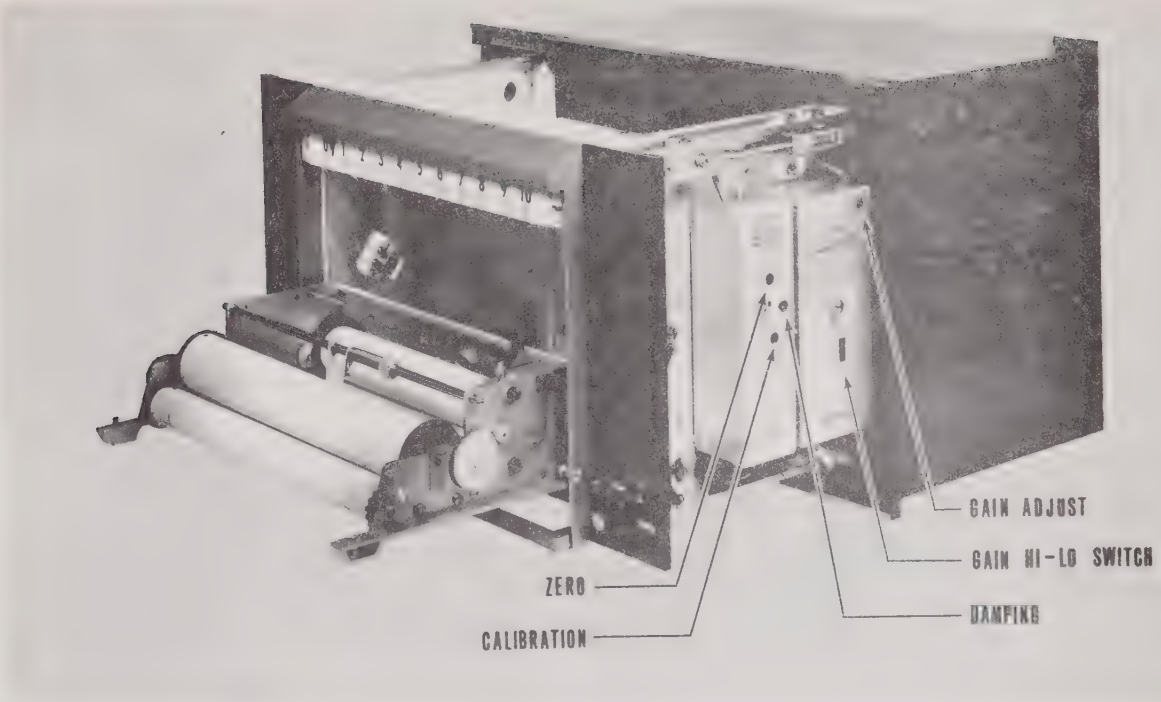


Figure 3-1. Chart Loading and Locations of Controls
(Wide Carriage Recorder Shown)

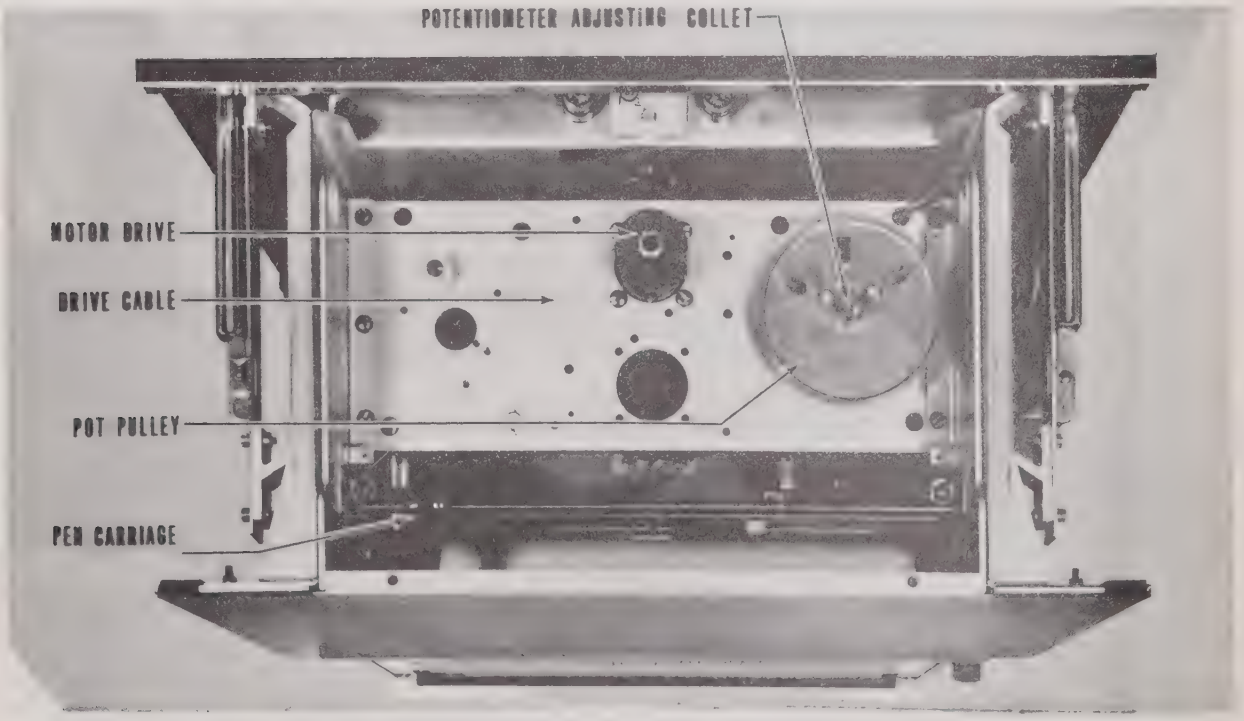


Figure 3-2. Servomotor Drive (Wide Carriage Recorder Shown

provided on each slide if the chassis is to be removed completely from the case. To remove the chassis completely from the case on the narrow-carriage recorder, lift up the chassis and pull it out.

3.4 ADJUSTMENT OF CONTROLS

The location of internal controls is illustrated in Figure 3-1.

WARNING

Some controls are located near or beneath the input cover. This cover is at the input potential above ground and if the input signal is at a dangerous potential above ground, this potential will be dangerous to personnel.

3.4.1 Power Switch

The power switch is located on the lower right front panel on the wide carriage recorder and inside the chassis rear panel (near the top of the recorder) on the narrow carriage recorder. It functions as follows:

Position	Description of Power
OFF	Both sides of the power disconnected from all circuits in the recorder with the exception of the fuses
STANDBY	Amplifier power on, servomotors and chart drive off
ON	All circuits on

3.4.2 Gain Adjust

The gain adjust is a screwdriver adjustment control in the upper right portion of the amplifier cover. The gain adjust provides continuous adjustment of the amplifier gain to obtain optimum deadband normally required only when changing recorder spans. For proper gain setting, advance the control clockwise until the deadband is less than 0.1% of the chart width or about equal to one-half the width of a pen line. Deadband is measured from two rest positions. The first is obtained by rotating the motor pulley or capstan clockwise (CW) until the pen deflects about 1%, allowing it to return slowly to rest (Figure 3-2). Then rotate the motor pulley counterclockwise (CCW) about 1% and again allow it to return slowly to rest. The difference in these two chart positions is the deadband.

NOTE

An excessive amount of gain will cause excessive pen jitter, poor dynamic response to large step input signals, and a higher sensitivity to interference signals.

3.4.3 Gain Hi-Lo Switch

The gain hi-lo switch, on the amplifier cover, places the gain adjust control in the correct dynamic range for the particular span used. For spans of 10 millivolts and lower, the switch should be in the up or HI position. For spans higher than 10 millivolts, the switch should be in the LO position.

3.4.4 Zero Control

The zero control is a screwdriver adjustment on the input cover providing approximately ±3% adjustment of the pen around the zero position chosen. Before attempting to adjust this control, make certain that the input signal is zero. Either short +, −, guard, and ground or reduce the signal source to zero. Check that the chart paper sprocket holes are aligned with the chart drive sprocket.

3.4.5 Damping Control

The damping control is a screwdriver adjustment control on the input cover. This control provides a small amount of adjustment of the dynamic performance or pen overshoot.

The damping control is factory set for optimum performance for most applications. Do not readjust unless the signal source resistance (external circuit resistance) approaches the recorder rating of 25,000 ohms. A step input signal is required for damping adjustment. If a step input cannot be obtained from the source, it may be obtained by the following steps.

a. Turn the recorder power switch to STANDBY.

b. Rotate the motor pulley to obtain the maximum pen displacement from the original balance point.

c. Return the power switch to ON.

Adjust the damping control for the desired amount of pen overshoot. Clockwise rotation of the control should reduce the amount of overshoot and counterclockwise rotation should increase the amount of overshoot.

3.4.6 Calibrate Control

The calibrate control, a screwdriver adjustment control on the input cover, provides approximately ± 2% span adjustment. The control is factory set for specified accuracy. Do not reset unless proper equipment is available and proper precautions are followed.

Since the servo/riter® II recorder is a precision measuring device, the equipment required to adjust the span should be relatively free of interference signals and supply a dc voltage accurate to 0.01 to 0.025% and equal to the span desired. Before attempting to calibrate the recorder, recheck and carefully reset the gain and zero control settings if required. The calibration voltage can then be applied and the calibrate control adjusted until

the pen rests exactly on the outer grid line of the chart. Because humidity changes affect chart paper width slightly, the instrument may be calibrated to the front scale if desired.

3.5 CHANGING RANGE CARDS

WARNING

Input cover is at input potential as described in Paragraph 3.4.

The range cards on the input board (Figure 3-3), made accessible by removing the input cover, are polarized and color coded to match the range card socket to prevent errors in replacement. The cover is held by one captive screw on its face. Schematics for three types of plug-in range cards of the basic recorder are shown in Figure 3-4. For other range cards refer to Section 6. The functions of the cards in Figure 3-4 are:

The upper or ZERO POSITION card determines the location of the ± 3% zero adjust range.

The middle or SPAN card determines the electrical span.

The lower or FUNCTION card determines the input form and is the same for all unsuppressed millivolt spans.

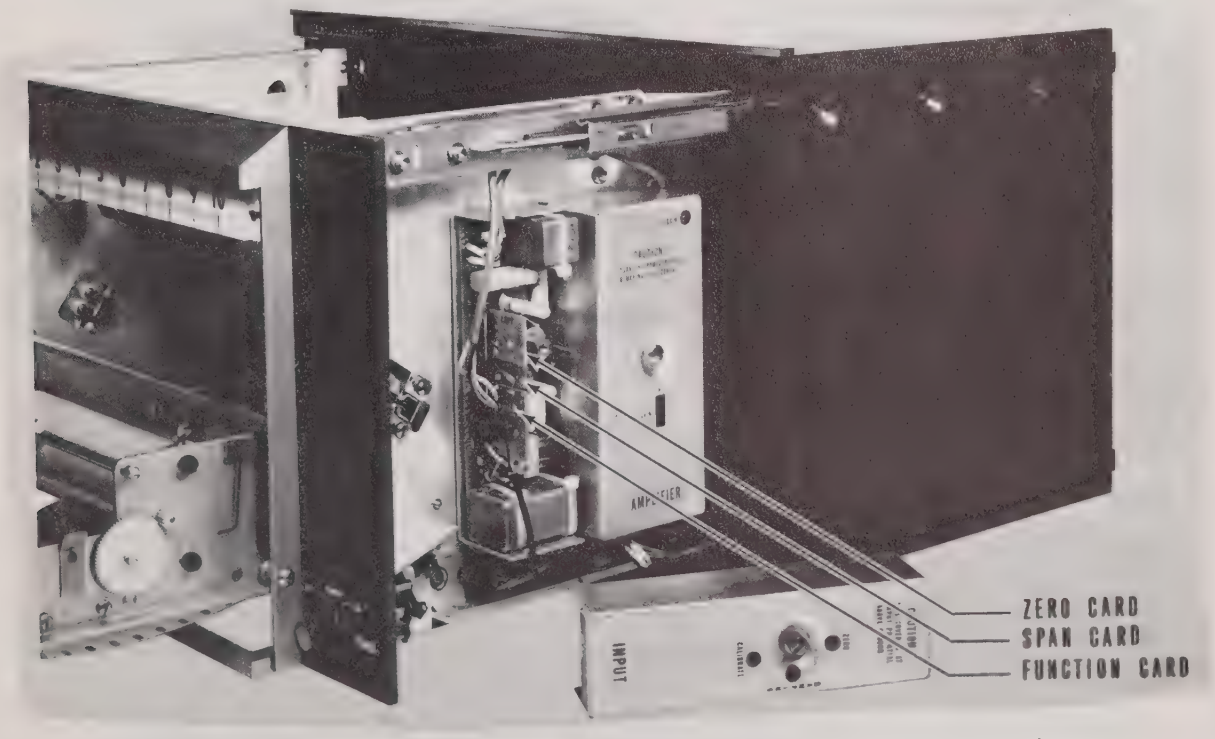


Figure 3-3. Input Board (Wide Carriage Recorder Shown).

SPECIAL RANGES

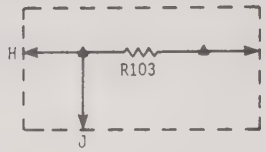
RANGES	
R101-Ω	
R102-Ω	
R103-Ω	
R104-Ω	
R105-Ω	
R106-Ω	
R107-Ω	

SPAN CARD

SPAN-MV	R103-Ω	SPAN-MV	R103-Ω
1	100	3	300.44
5	501.45	11	1108
10	1006.6	4	400.8
50	5184.3	30	3064.38
100	10,774	44.338	4577.44
5.5	551.8	40.875	4181.02
32.5	3326	75	7924.50
20	2027.96	90	9618.3
1.027	102.70	109.09	11,836
25	2544.31	12	1209.6
26.10	2658.42	129.6	14,290.00
2.625	262.81	1.50	150.05
40	4116.4	18	1822.45
32	3273.54	55	5723.96
110	11,943		

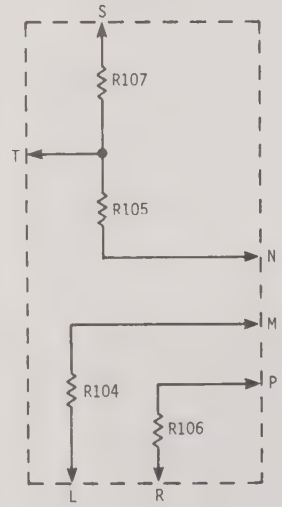
B184919AB
3-12-68

SPAN CARD

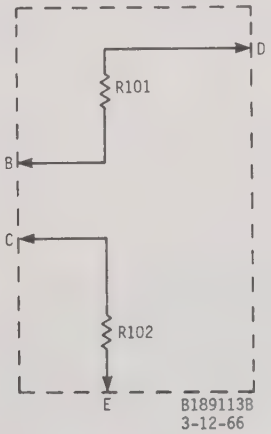


▲ INDICATES LOW THERMAL EMF SOLDER JOINT

FUNCTION CARD



ZERO POSITION CARD



ZERO POSITION CARD

ZERO POSITION FROM LEFT MARGIN	R101-Ω	R102-Ω
LEFT (0%)	1400	68
RIGHT (100%)	68	1400
CENTER (50%)	750	750
SUPPRESSED	9360	68
10/100 FROM RIGHT MARGIN	189	1279
5/110	1340	128
33/100	956	512
43.4/100	822	646
70/100	468	1000
9.1/100	1279	189
25/100	1067	401
75/100	401	1067
34.6/100	939	529
69.2/100	478	990
4.76/100	1336.6	131.4
10/110	1279	189
3%	1360	108
6%	1320	148
9%	1280	188
12%	1240	228
15%	1200	268
18%	1160	308
21%	1120	348
24%	1080	388
27%	1040	428
30%	1000	468
33%	960	508
36%	920	548
39%	881	587
42%	841	627
45%	801	667
48%	761	707
52%	707	761
55%	667	801
58%	627	841
61%	587	881
64%	548	920
67%	508	960
70%	468	1000
73%	428	1040
76%	388	1080
79%	348	1120
82%	308	1160
85%	268	1200
88%	228	1240
91%	188	1280
94%	148	1320
97%	108	1360
ELEVATED	68	9360
	128	1340

B172551L
3-14-68

FUNCTION CARD

DESCRIPTION	R104-Ω ±0.1%	R105-Ω ±0.1%	R106-Ω ±0.1%	R107-Ω ±0.1%
W/O SUPPRESSION	138,000	JUMPER	JUMPER	173.0
W/O SUPPRESSION (0:1)	138,000	140.538	JUMPER	34.92
W/O SUPPRESSION (1:1)	138,000	117.115	23.423	34.92
W/O SUPPRESSION (2:1)	138,000	93.692	46.846	34.92
W/O SUPPRESSION (3:1)	138,000	70.269	70.269	34.92
W/O SUPPRESSION (4:1)	138,000	46.846	93.692	34.92
W/O SUPPRESSION (5:1)	138,000	23.423	117.115	34.92
W/O SUPPRESSION (6:1)	138,000	JUMPER	140.538	34.92
W/O SUPPRESSION (0.5:1)	138,000	128.826	11.7115	34.92
W/O SUPPRESSION (0.25:1)	138,000	134.682	5.856	34.92
W/O SUPPRESSION (4.5:1)	138,000	105.404	35.134	34.92

B189113B
3-12-66

TP107

Figure 3-4. Schematic, Millivolt Range Card

3.6 CHART CARRIAGE

3.6.1 Selection of Change Gears

Six change gears are supplied with the basic chart carriage, providing five different chart speeds with each chart drive motor. Each gear is stamped to show the number of teeth. Tables 3-1 and 3-2 present data for gear selection (Table 1-1 is filled in on manuals shipped to accompany instruments and shows code number of the motor).

The change gears in use are on the right side of the chart carriage and can be seen when the carriage is swung open. The change gears not in use are stored on a long screw mounted behind the takeup area. A multispline setscrew wrench is supplied and secured in a clip on the right side of the carriage.

Other change gears that are available include the following ratios: 3:10, 1:3, 3:8, 2:5, 3:7, 3:5, 2:3, 3:4, and 4:5. These gears can be used as step-down or step-up ratios. Two other sets, 1:5 and 1:6, are available as step-down ratios only.

3.6.2 Motors

The AE, BE, CE, DE, AM, BM, CM and DM motors are designed for quick, easy changing so the recorder can be used for different speed ranges with a minimum of downtime and effort.

Changing these motors requires only the following steps.

a. Remove lower change gear from motor shaft.

b. Remove the two black thumbnuts that secure motor to chart carriage.

c. Pull motor off carriage, unsnap motor cable clip from carriage cross rod, and unplug motor cable connector.

d. Install the new motor by doing steps a. to c. in reverse order.

Requirements of the system dictate that the higher-speed motors be changed by competent personnel.

3.6.3 Other Features

The front platen on the chart carriage supports the chart and provides a surface for marking on the chart. The small groove across the platen surface permits easy tearoff of the chart by running a coin, thumbnail, or pencil point across the groove.

A friction clutch and thumbwheel on the chart drive sprocket permit manual advancement or slight backup of the chart.

When using the recorder without the takeup, clip a large paper clamp or other small weight (2 ounces) to the bottom edge of the chart.

TABLE 3-1

CHANGE GEAR SELECTION, STANDARD (INCH) SPEEDS

Chart Speed Desired	Motor Code	Output Shaft Speed Required	Gears Required (No. of Teeth) and Gear Position	
			Upper	Lower
0.25 iph	AE	4 rph	72	18
0.5 iph	AE	4 rph	60	30
1.0 iph	AE	4 rph	45	45
2.0 iph	AE	4 rph	30	60
4.0 iph	AE	4 rph	18	72
1.5 iph	BE	24 rph	72	18
3.0 iph	BE	24 rph	60	30
6.0 iph	BE	24 rph	45	45
12.0 iph	BE	24 rph	30	60
24.0 iph	BE	24 rph	18	72
2.5 iph	CE	40 rph	72	18
5.0 iph	CE	40 rph	60	30
10.0 iph	CE	40 rph	45	45
20.0 iph	CE	40 rph	30	60
40.0 iph	CE	40 rph	18	72
0.25 ipm	DE	4 rpm	72	18
0.5 ipm	DE	4 rpm	60	30
1.0 ipm	DE	4 rpm	45	45
2.0 ipm	DE	4 rpm	30	60
4.0 ipm	DE	4 rpm	18	72
1.5 ipm	EE	24 rpm	72	18
3.0 ipm	EE	24 rpm	60	30
6.0 ipm	EE	24 rpm	45	45
12.0 ipm	EE	24 rpm	30	60
24.0 ipm	EE	24 rpm	18	72
2.5 ipm	FE	40 rpm	72	18
5.0 ipm	FE	40 rpm	60	30
10.0 ipm	FE	40 rpm	45	45
20.0 ipm	FE	40 rpm	30	60
40.0 ipm	FE	40 rpm	18	72
7.5 ipm	GE	120 rpm	72	18
15.0 ipm	GE	120 rpm	60	30
30.0 ipm	GE	120 rpm	45	45
60.0 ipm	GE	120 rpm	30	60
120.0 ipm	GE	120 rpm	18	72

TABLE 3-2

CHANGE GEAR SELECTION, METRIC SPEEDS

Chart Speed Desired	Motor Code	Output Shaft Speed Required	Gears Required (No. of Teeth) and Gear Position	
			Upper	Lower
0.625 cm/hr	AM	4 rph	72	18
1.25 cm/hr	AM	4 rph	60	30
2.5 cm/hr	AM	4 rph	45	45
5.0 cm/hr	AM	4 rph	30	60
10.0 cm/hr	AM	4 rph	18	72
3.75 cm/hr	BM	24 rph	72	18
7.5 cm/hr	BM	24 rph	60	30
15.0 cm/hr	BM	24 rph	45	45
30.0 cm/hr	BM	24 rph	30	60
60.0 cm/hr	BM	24 rph	18	72
6.25 cm/hr	CM	40 rph	72	18
12.5 cm/hr	CM	40 rph	60	30
25.0 cm/hr	CM	40 rph	45	45
50.0 cm/hr	CM	40 rph	30	60
100.0 cm/hr	CM	40 rph	18	72
0.625 cm/min	DM	4 rpm	72	18
1.25 cm/min	DM	4 rpm	60	30
2.5 cm/min	DM	4 rpm	45	45
5.0 cm/min	DM	4 rpm	30	60
10.0 cm/min	DM	4 rpm	18	72
3.75 cm/min	EM	24 rpm	72	18
7.5 cm/min	EM	24 rpm	60	30
15.0 cm/min	EM	24 rpm	45	45
30.0 cm/min	EM	24 rpm	30	60
60.0 cm/min	EM	24 rpm	18	72
6.25 cm/min	FM	40 rpm	72	18
12.5 cm/min	FM	40 rpm	60	30
25.0 cm/min	FM	40 rpm	45	45
50.0 cm/min	FM	40 rpm	30	60
100.0 cm/min	FM	40 rpm	18	72
18.75 cm/min	GM	120 rpm	72	18
37.5 cm/min	GM	120 rpm	60	30
75.0 cm/min	GM	120 rpm	45	45
150.0 cm/min	GM	120 rpm	30	60
300.0 cm/min	GM	120 rpm	18	72

SECTION 4

THEORY AND DEFINITIONS

4.1 NULL-BALANCE RECORDER THEORY

Fundamentally, a null-balance potentiometric recorder consists of display, feedback generating, and error-detecting and amplifying functions as shown in Figure 4-1. A voltage to be measured is connected to the recorder in opposition to an internally generated feedback voltage. The difference between the voltage to be measured and the internally generated feedback is applied as the input to an amplifier. The amplifier output drives a motor which drives a potentiometer that changes the internally generated voltage until the difference voltage is very small. The motor then stops running, and the pen or print head (display element) records the amount of voltage measured. Very little current is drawn from the voltage source being measured because it is balanced by the internal feedback voltage.

4.1.1 Damping

In addition to these basic functions, the recorder needs damping. With a sudden change in the input signal, the error voltage may be sufficient to

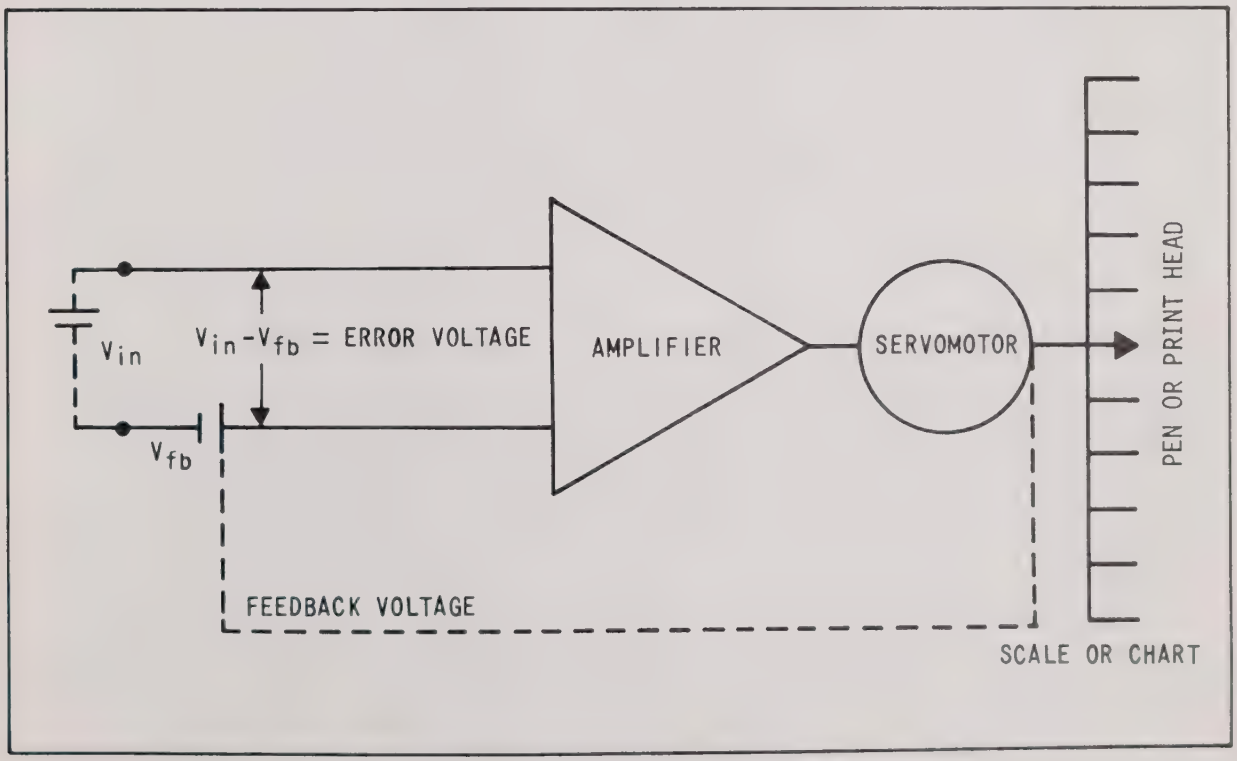


Figure 4-1. Simplified Recorder Diagram

run the motor at full speed. But when the error voltage reaches zero, the motor inertia prevents a sudden speed drop to zero. Without damping the recorder can overshoot the proper balance point and go into steady oscillation, first overshooting on one side and then the other of the balance point. The damping system develops a voltage proportional to the speed and feeds it into the amplifier so that the motor torque generated stops just as the feedback voltage equals the voltage to be measured.

4.1.2 Filtering

A filtering system reduces stray voltages in the system. For a recorder design of 1-millivolt full-scale measurement, the amplifier gain must be such that an input of approximately 20 microvolts drives the amplifier into saturation. This illustrates the importance of eliminating stray voltages.

To reduce the effect of stray ac voltages on the system, a low-pass filter is placed in cascade with the input. This filter is designed to pass the signal frequencies and block higher frequencies.

4.1.3 Common-Mode Isolation

It is possible for the voltage source to be measured to be at some ac or dc voltage with respect to ground. Isolation is necessary to measure the voltage of the source without having the measurement upset. The portion of the system generating the feedback and error voltage, and possibly some portion of the amplifier, must be isolated so the effective error voltage is not affected by voltages with respect to ground. This function is called common-mode isolation.

There are a number of methods used to accomplish common-mode isolation. In the servo/riter® II and multi/riter* the dc error signal is converted to an ac signal and passed through a carefully designed input transformer which passes the signal but does not pass common-mode voltages. All the circuitry on the primary side is isolated from ground, but the secondary feeds an amplifier which uses ground as reference.

The error amplifier must respond to less than 0.1% of the span of the recorder (1 microvolt for 1-millivolt span), and have a dc stability comparable to its sensitivity. This degree of stability is obtained by changing the dc error signal to ac in a modulator and amplifying the ac in an ac amplifier. The amplifier output is then fed to the servomotor as previously described.

---

*Trademark of Texas Instruments Incorporated

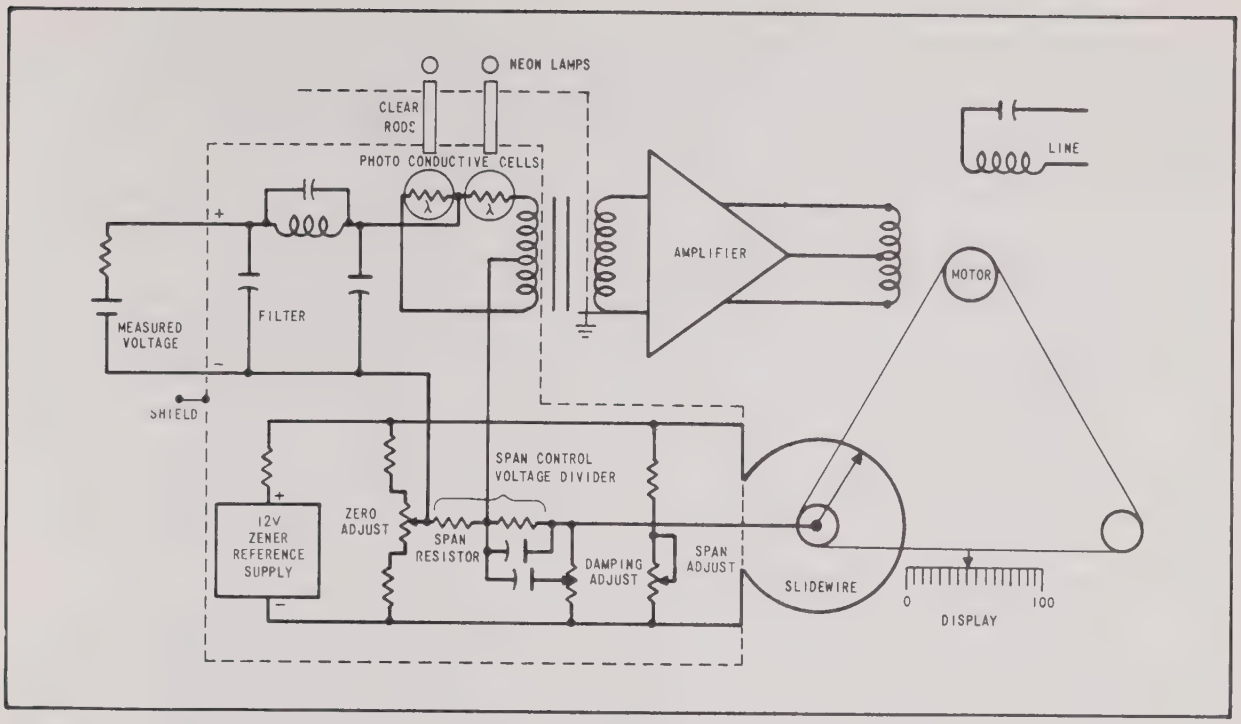


Figure 4-2. Simplified Recorder Schematic

4.1.4 Theory of the servo/riter® II and multi/riter* Recorders

Figure 4-2 is a simplified schematic representation of the servo/riter® II and multi/riter* recorders. The display element is a pen (print head in the multi/riter* recorder) moving across a paper chart which is advanced by a synchronous motor. Subsections 4.2 through 4.7 explain the theory of the recorder in detail.

4.2 FEEDBACK

The feedback element is a circular continuous wire. A stable voltage is impressed across the element from a zener-diode regulated power supply. The contact to the resistance element is mechanically coupled to the display element by a flexible stainless-steel cable, pulleys, and a ball-bearing mounted shaft. This coupling causes the contact to move accurately along a circle as the display element moves linearly. The same stainless-steel cable is wound on a pulley on the servomotor shaft.

The high resolution of a single strand of wire makes it desirable for the resistance element. The active region of the wire is approximately 27 ohms, and the total resistance is approximately 32 ohms. Making all the wires and connections follow paths close to the main slidewire results in a minimum of

magnetic-field pickup. The sliding contact of the feedback element bridges from the slidewire to a pickup wire rather than from a pickup circuit along the pickup arm. The recorder is designed for easy span change. Consequently, for all normal spans, the voltage across the active portion of the wire is maintained at a fixed value of about 1.38 volts.

To obtain the proper voltage for recorders of 1-millivolt to 100-millivolt span, the slidewire span of 1380 millivolts is reduced by a resistance divider. One of the resistors in the divider, 138 kilohms, is the dropping resistor. The other resistor, across which the feedback voltage is developed, varies from 100 ohms for a 1-millivolt span up to 10,780 ohms for 100-millivolt span. This resistor is called the feedback resistor.

To control the point at which the recorder reads zero, the voltage impressed across the slidewire is also impressed across a second resistance divider. The span-controlling divider is returned to the point on this divider which matches the potential on the main slidewire, the place which corresponds to the display element position indication of zero.

The main damping function in this recorder is provided by a capacitor which shunts the 138-kilohm dropping resistor in the span-controlling divider. When the slidewire contact is in motion , the voltage across the capacitor is changing. This causes a current, which also flows through the feedback resistor, to flow through the capacitor. This extra current through the feedback resistor causes the dynamic feedback voltage to lead the static feedback voltage. Thus, the feedback voltage matches the input voltage a short time before the display element comes to the final balance point, and a reversed error signal is applied to the amplifier sufficiently in advance of the balance point to bring the motor to a stop without overshooting. A second smaller capacitor is connected to a high-resistance variable voltage divider. The voltage divider is connected from the slidewire contact to one end of the slidewire to provide a means of varying the damping.

4.3 FILTERING

The recorder filter consists of one RC section and one RLC section. A resistor added in series with the choke prevents a series resonant rise in the filter due to signal frequencies. Also, an undamped filter choke will cause the recorder to overshoot when step input signals of certain amplitudes are applied. The series resistor eliminates this effect.

The outer case of the filter choke is made from very high permeability nickel-iron laminations. A small airgap is left to prevent momentary overvoltages applied to the recorder input from saturating the choke.

The modulator in the recorder uses two photoconductive cells. These cells have a low resistance when illuminated and a high resistance when dark. Two neon lamps are used to illuminate the photoconductors. One lamp is on during one half cycle of the power line and the other lamp is on during the alternate half cycle.

The error voltage is switched to alternate ends of the input transformer centertapped primary through the illuminated photoconductive cell. Approximately 100 volts is required to fire the neon lamps. Spacing the lamps about 2-1/2 inches from the photoconductors and guiding the light through clear rods prevents any stray 60 cycles in the low-level error signals which are passing through the modulator.

The input transformer is equipped with separate electrostatic shields enclosing the primary and the secondary. The 2:1 stepdown ratio presents the first-stage transistor of the error amplifier with the proper source impedance value for low noise. The input transformer has an open circuit primary impedance of more than 100,000 ohms at 60 Hz. However, because of special circuitry in the error amplifier, the effective dc impedance presented by the modulator to the error voltage is about 200,000 ohms.

4.4 ERROR AMPLIFIER

The error amplifier following the input transformer uses transistors for all stages. The push-pull output stage feeds into a centertapped control winding on a two-phase servomotor. The phase shift through the amplifier is nominally zero. The voltage applied to the reference phase of the motor is shifted 90° by the use of a series capacitor. For a 1-millivolt span, detection sensitivity is 0.5 microvolt and the error for amplifier saturation is approximately equal to 2%.

As seen in the schematic (Figure 4-3), the amplifier first stage (transistor Q1) is operated at low voltage and current (about 600 millivolts, 140 microamperes) for low noise. The second stage is an emitter-follower which presents a high impedance to the first stage for a high voltage gain, and a low impedance to the third stage to make the gain dependent more on the transistor transconductance than on the current gain. This is desirable because transconductance of a transistor varies less than its current gain with temperature.

The third-stage voltage output is divided (R14 and R8) by a factor of 1100 and fed back negatively through the first-stage emitter-bypass capacitor to Q1. This negative feedback further stabilizes the voltage gain and reduces the phase shift. There is also a positive feedback path to the first stage through R12 and R2 and R3. The positive feedback cancels much of the input transformer loading produced by R1 and also cancels some of the input transformer losses. This circuit makes it possible to keep R1, which provides a base current path for Q1, low in resistance. This improves the first-stage temperature stability and still keeps the input impedance of the amplifier high.

The Q3 output is fed through a gain-adjustment potentiometer R15 and coupling capacitor C12 to Q4. Q4 has local feedback through the unbypassed R23 in the emitter. A switch is provided to add a much larger unbypassed

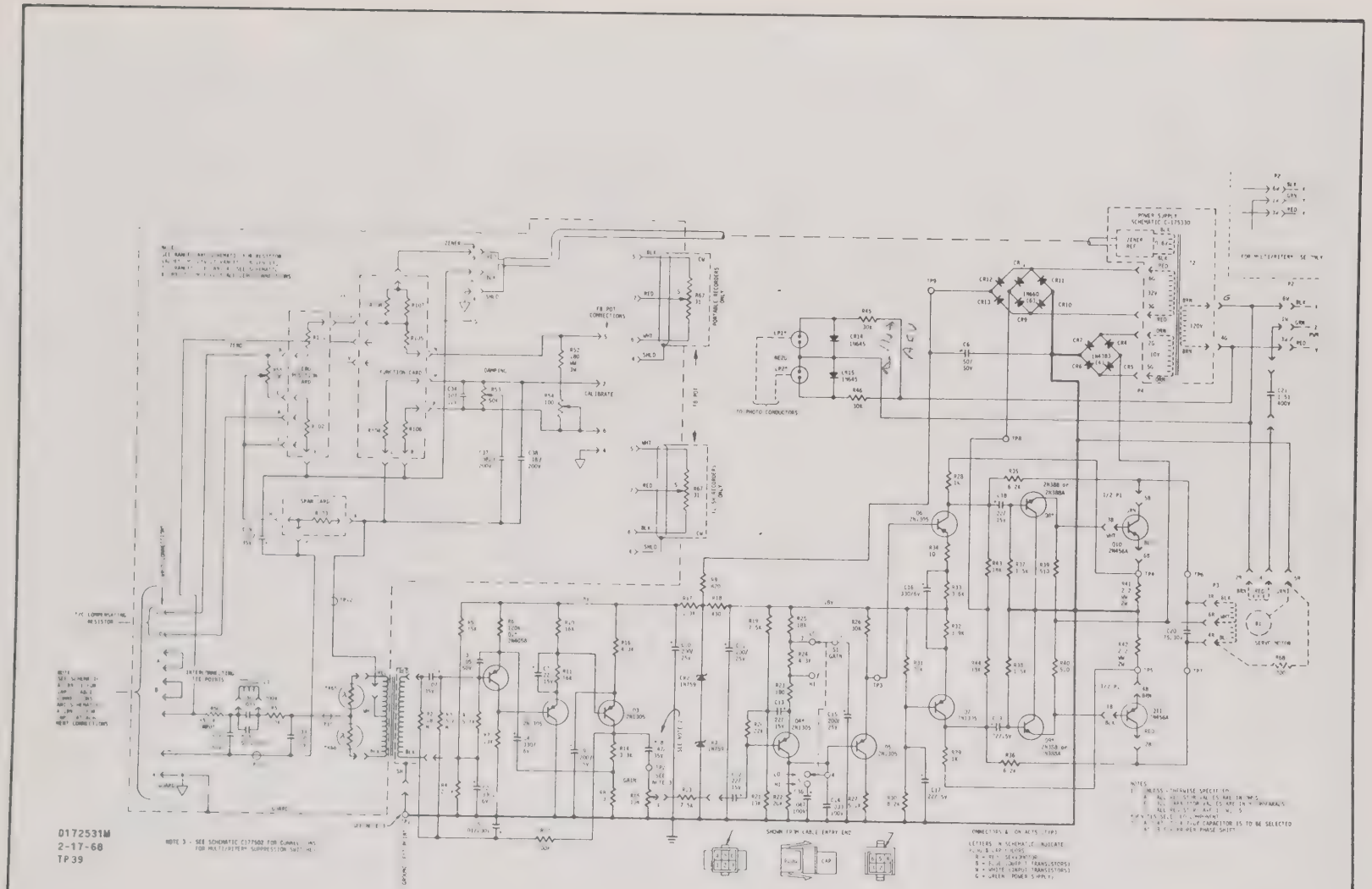


Figure 4-3. Schematic, Amplifier and Input

resistor, R24, in series with the emitter to reduce the gain by a factor of approximately six. This gives wide-span recorders a better resolution than if the gain change of 100:1 (to take care of the spans from 1 millivolt to 100 millivolts) were provided by the single gain-adjustment potentiometer.

R13 reduces the saturation effects in the fourth stage resulting from full-scale step-input signals. C14 shunted across the collector load resistor of Q4 controls the frequency bandwidth of the amplifier and provides for zero phase shift for the overall amplifier. Q5 is an emitter-follower with an impedance-matching function similar to Q2. The differential amplifier stage (Q6 and Q7) provides additional gain and two output signals of opposite phase for exciting the push-pull output stage.

The two differential stage outputs are fed through coupling capacitors to the emitter-follower drivers. The drivers are directly coupled to the bases of the push-pull power transistors which drive a centertapped servomotor control winding.

Negative feedback in the output stage from the motor through R35 and R36 lowers the output impedance. A negative feedback also is provided by resistors R41 and R42 in series with the emitters of the power transistors Q10 and Q11. This feedback increases the dc stability if ambient temperature changes occur. To offset any disadvantage in the ac signal path, connections are made from R41 to R28 and R42 to R29.

The currents flowing through R43 and R44 cancel an undesired ripple from the unfiltered output stage power supply passing through R35 and R36. This second harmonic ripple, which is produced under no-signal conditions, would increase the power dissipation in the power transistors.

4.5 REFERENCE POWER SUPPLY UNIT

The reference power supply is a highly accurate dc voltage source with excellent stability and reliability for rated conditions of temperature, line voltage and frequency. The unit consists of a solid-state voltage-regulator circuit with a temperature-compensated zener-diode reference element. The output voltage is 12.00 ± 0.03 volts at 0 to 65 milliamperes of load current and is factory adjusted to provide optimum line voltage regulation. A continuous short or open across the output will not damage the unit. Figure 4-4 shows the power supply board assembly.

Power transformer T2 (Figure 4-5) provides approximately 0.8 volt to the primary of transformer T1 which steps this voltage up to 25 volts ac in the shielded secondary. This arrangement produces a fairly high supply voltage to the rectifier circuit and minimizes the ac common-mode stray pickup. The ac voltage is rectified and filtered by the bridge rectifier (CR1-CR4) and capacitor C2.

The series voltage regulator consists of dual emitter-follower transistors Q1 and Q2 driven by a differential output error amplifier,

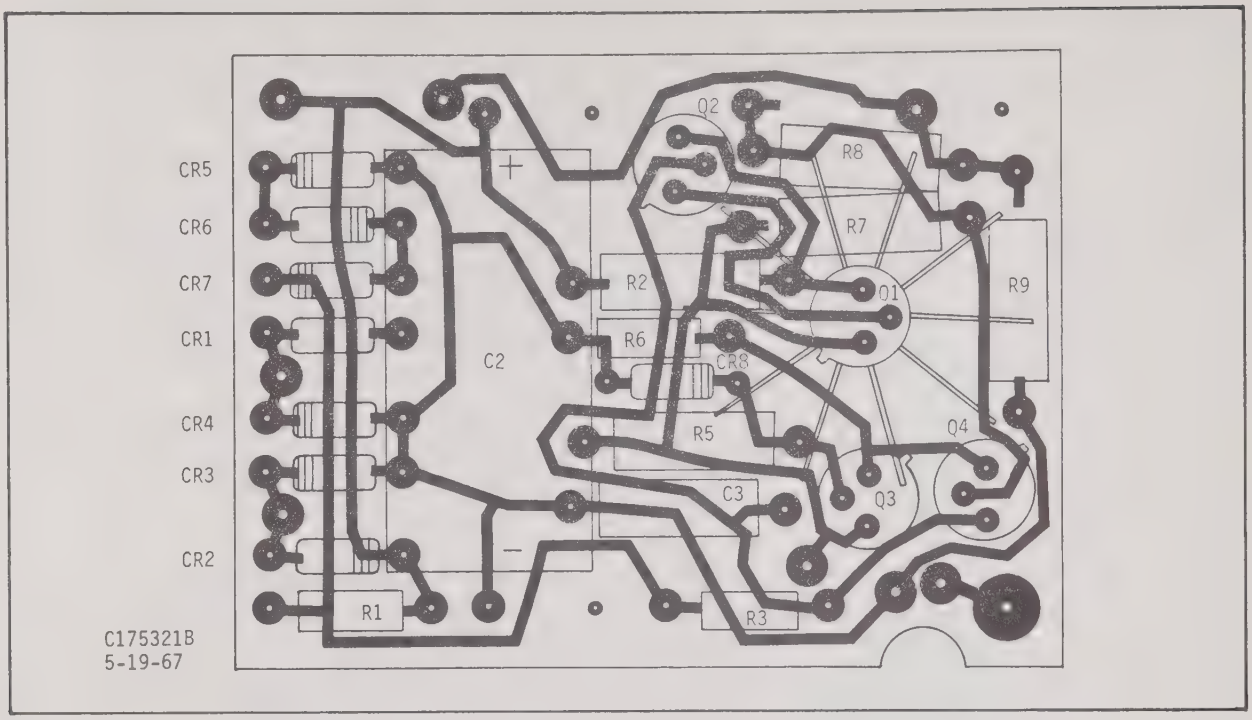


Figure 4-4. Power Supply Board Assembly

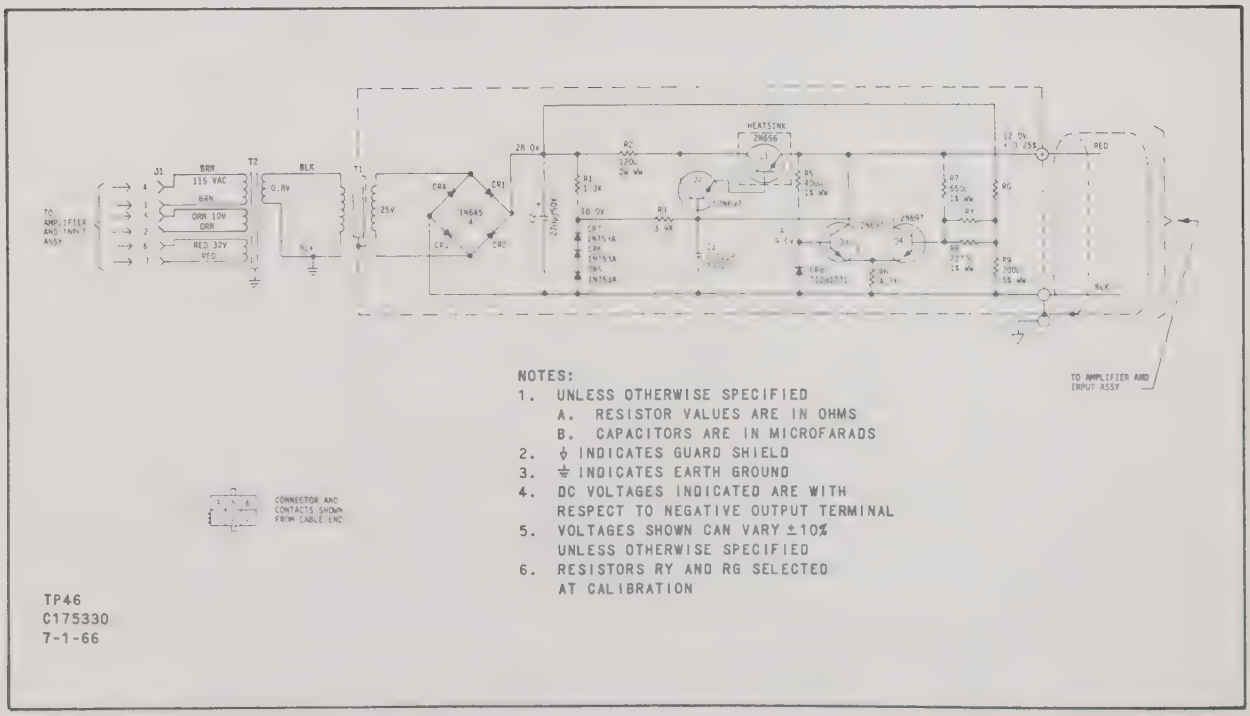


Figure 4-5. Schematic, Power Supply

transistors Q3 and Q4. CR8 is a temperature-compensated zener diode that provides a reference voltage for the system and biases Q3. Resistors RY, R8 and R9 form a voltage divider circuit across the output and bias Q4. RY is adjusted at the factory to obtain the desired output voltage. A change in the output voltage, detected at the base of Q4, will drive Q1 and Q2 to correct the change in voltage.

RG provides a feedforward path for cancellation of line regulation effects and output ripple. RX is selected to match the V_{BE} parameters of Q3 and Q4 at the desired output voltage. C3 modifies the gain-phase characteristic of the error amplifier to provide margin against high-frequency instability. The regulator will not oscillate when a capacitor is connected across the regulated output terminals.

4.6 CHART CARRIAGE

The chart carriage assembly provides chart drive and the chart control function. A synchronous motor geared to a chart driving sprocket engages precision holes in the chart. The supply roll is held in place just below the drive sprocket. A spring-loaded finger presses against the outer layer of the chart paper, providing an essentially constant holdback tension of about 3 ounces. The chart passes down the carriage front to the takeup tube at the carriage bottom. A constant-torque slip clutch is driven more than twice as fast as the chart driving sprocket. The takeup tube is driven through this slip clutch. The takeup chart tension varies by a factor of 2-1/2 times because of the varying diameter of the takeup roll. Normally, the actual takeup tension varies from more than 4 ounces at the start of a roll to less than 2 ounces at the finish.

A constant torque brake is provided on the chart driving sprocket so that the chart will not back up when the chart roll tension is lessened. A high-torque slip clutch is also provided on the chart sprocket to permit manual override to position a selected timing line of the chart directly under the display element at the start of a timed run.

Various optional drives are available in place of the standard low-speed motor drive. Section 6 lists these drives.

4.7 DEFINITIONS

The definitions which follow are quoted from the American Standards specifications for "Automatic Null-Balancing Electrical Measuring Instruments" (C39.4 - 1956). The servo/riter® II and multi/riter* recorder external circuit resistance is normally limited by an increase in its step response time or a reduction of its frequency response before it is limited by deadband increase or shifting of deadband. ASA Specification C39.4, 1956, states that the rated external circuit resistance shall cause no more than 20% increase in span step response.

DEFINITIONS

Accuracy Rating. The accuracy rating of the instrument is the limit which errors will not exceed when the instrument is used under any combination of rated operating conditions. It is expressed as a percent of the span or as a fixed value in the units of the measured quantity. The accuracy rating does not include primary detectors or intermediate means external to the instrument.

Deadband. Deadband is the range through which the measured quantity can be varied without initiating response. This is usually expressed in percent of span.

External Circuit Resistance. The external circuit resistance is the resistance of that part of the measuring circuit which is external to the instrument.

External Circuit Resistance Rating. The external circuit resistance rating is the value of external resistance which when injected in an external circuit having substantially zero resistance, will either: (1) double the deadband, or (2) shift the deadband by one-half its width.

Extreme Operating Conditions. Extreme operating conditions denote the limits of specified variables or conditions within which the instrument may be operated. Under these conditions, the performance ratings do not necessarily apply.

Interference. Interference is any spurious voltage or current appearing in the circuits of the instrument.

Interference, Transverse. Transverse interference is a form which appears as a voltage between measuring circuit terminals.

Interference, Longitudinal. Longitudinal interference is a form which appears between measuring circuit terminals and ground.

Interference, Magnetic-Field. Magnetic-field interference is a voltage or current induced in the circuits of the instrument due to the presence of a magnetic field. It may appear as transverse or longitudinal interference in the measuring circuits or may affect other parts of the instrument.

Measurand. The measurand is a physical quantity, property, or condition which is to be measured.

Measured Quantity. The measured quantity is the electrical variable applied to the measuring circuit terminals of the instrument and is the electrical equivalent of the measurand.

Null Balance. As applied to instruments within the scope of this American Standard, null balance is the condition which exists in the circuits of an instrument when the difference between an opposing electrical quantity within the instrument and the measured quantity does not exceed the deadband. The value of the opposing electrical quantity produced within the instrument is related to the position of the end device.

Operating Influence. The operating influence of a specified variable or condition on an instrument is the change in a designated performance characteristic caused solely by a prescribed change in a specified operating condition, all other operating conditions being held within the limits given for test conditions. If the magnitude of the influence is affected by direction, polarity, or phase, the greater value shall be taken.

Performance Ratings. Performance ratings are the limits of the values of certain operating characteristics of the instrument which will not be exceeded under any combination of rated operating conditions.

Range. The range of an instrument is the region covered by the span and is expressed by stating the two end-scale values. If the span passes through zero, the range is stated by inserting "zero" or "0" between the end-scale values.

Range, Electrical. Electrical range is the range expressed in equivalent electrical units.

Range, Scale. Scale range is the range expressed in scale units.

Range, Suppressed Zero. A suppressed zero range is an instrument range which does not include zero.

Rated Operating Conditions. Rated operating conditions denote the limits of specified variables or conditions within which the performance ratings apply.

Reproducibility. Reproducibility is the ability of the instrument to produce consistently the same position of the end device for the same value of the measured quantity under the same conditions of operation.

Response, Frequency. Frequency response is a criterion of the dynamic response of an instrument when the measured quantity is varied sinusoidally over a band of frequencies. It is usually expressed as the output-to-input amplitude ratio versus frequency and the phase shift between output and input versus frequency.

Span. The span of an instrument is the algebraic difference between its end-scale values.

Span, Electrical. Electrical span is the span expressed in equivalent electrical units. It is the change in the measured quantity to cause the end device to travel between scale limits.

Span, Scale. Scale span is the span expressed in scale units.

Step Response Time. Step response time is the time required for the end device to come to rest in its new position after an abrupt change to a new constant value has occurred in the measured quantity.

Suppression Ratio. The suppression ratio is expressed as the ratio of the electrical equivalent of the smaller end-scale value to the electrical span. (For example, the suppression ratio is 2 for a range of 20 to 30 millivolts or for a range of −30 to −20 millivolts.)

SECTION 5

MAINTENANCE AND TROUBLESHOOTING

5.1 REMOVAL OF DUST COVER (Portable Models)

For bench maintenance the dust cover may be completely removed. Remove the screws on each side and unwind the power cord. Place thumbs on the front edge of the dust cover. Press out and lift off the cover.

WARNING

Before doing repair or maintenance, pull the power plug.

5.2 TROUBLESHOOTING SERVO MEASURING SYSTEM

The following simple checks and repairs involve checks which can be made with a multimeter only. These troubles can be repaired without soldering operations on the printed circuit boards. This section also serves as an aid in localizing the troubles.

5.2.1 Recorder Pen Drives Against Stop

If the recorder pen drives to one side of the chart against the stop:

a. Check that the signal does not exceed the span of the recorder.

b. Check for disconnection or failure of the reference power supply.

c. Measure the 12-volt reference power supply output voltage at the end of the cable coming through the bottom of the input side of the board and going to pins 8 and 9 next to the connector.

d. Check the cable connections to the board at pins 4, 5, 6, and 7 beside the 18-point connector to see that the feedback slidewire is not disconnected.

e. Check the resistance back through the cable with an ohmmeter. The resistance between the white and black leads should be approximately 31 ohms. The resistance from the red lead to white or black lead varies with the pen position.

f. Check that the range cards are not missing or making bad contact.

If a motor or amplifier has been changed, a phase reversal may have occurred. A signal within the span of the recorder will then drive the recorder pen against either the zero stop or high end stop instead of a balance position. This can be corrected by interchanging connections 1 and 2 on the red connector:

a. To interchange the connections, first separate the connectors.

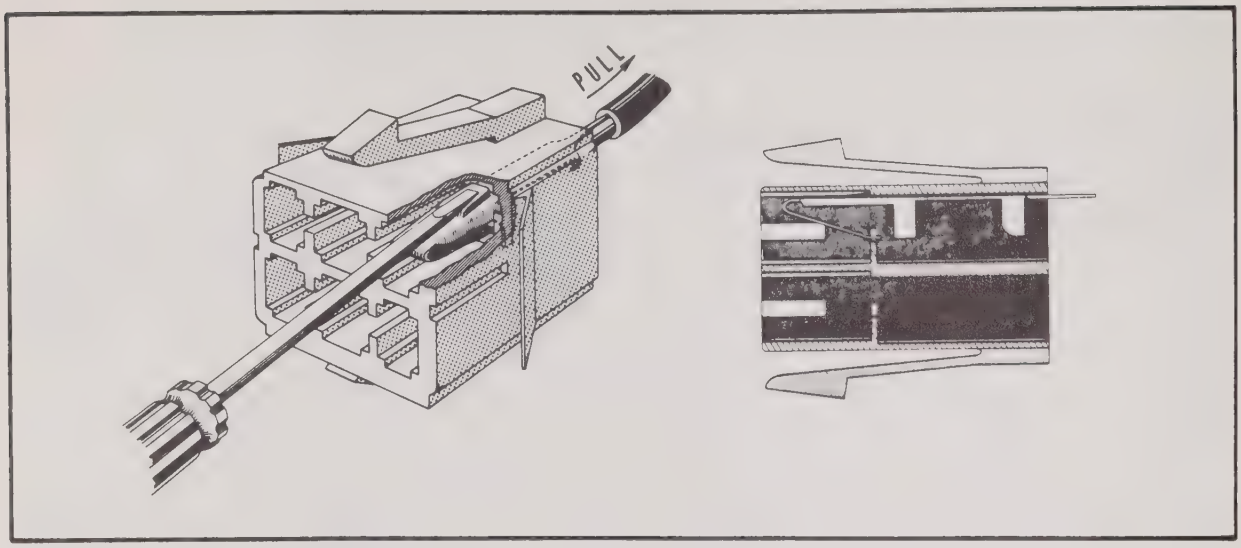


Figure 5-1. Removing Connections

b. Wedge a screwdriver blade (Figure 5-1) between the chassis and the edge of the connector and twist to unplug the connector. The metal connection points are held in place by small projecting metal tabs. If the tabs are compressed with a pair of tweezers or a screwdriver is inserted, the metal connections can be pulled out of the back of the connector and interchanged.

5.2.2 Dead Servomotor

Power is connected to the recorder and the input is connected to a signal or a short. The switch is ON but the motor does not develop any motion or torque (except gear friction torque) when the dead zone test knob is turned, and the pen stays wherever it is placed.

Proceed with the following checks:

a. Turn the gain adjust clockwise to be sure the error amplifier gain has not been set to zero.

b. Turn off the power and remove the amplifier cover. After the cover is removed, turn the power on. If the neon lamps in the block (from which the plastic rods emerge) fail to light, it is probable that no power is getting to the system.

c. Check the fuses.

d. Check the white connector to the amplifier board to see that it is tightly in place.

NOTE

The small probes from a multimeter will fit in the back of the connector alongside the wires and make contact to inserts of the connectors.

e. Tug gently on the wires leading to the connector to see if they are broken or if the metal inserts in the connector are loose.

f. Read the line voltage between point TP6 and either point TP1 or TP3. Figure 4-3, Schematic, Amplifier and Input, gives number codes. If no voltage is present, trace wiring to back of recorder chassis to determine if one of the quick-disconnect terminals is off.

g. With power indicated on the board by the neon lamps, check the voltage across the large mylar capacitor (C21) in series with the motor reference phase. This should be about 165 volts for a 120-volt line.

NOTE

References R, G, B, and W are abbreviations for red, green, black, and white, respectively, and refer to the color of the connector. For example, 1R denotes pin 1 of the red connector.

h. If this voltage is absent, turn off the power and check the circuit through the red connector and the motor winding. The resistance of the reference phase of the motor should be about 320 ohms (measured between 1R, 2R). Also check for broken wires and loose connectors.

i. Check that the voltages coming to the circuit board from the power transformer are 10 volts ac across point 5G and 2G on the board and 32 volts ac between 3G and 6G.

j. If either of these voltages is absent, turn off the power and check connections back to the transformer through the green connector. The resistance of the 32-volt winding should be 55 ohms. The resistance of the 10-volt winding should be 0.5 ohm.

k. Turn off the power. Check the connections to the servomotor by a resistance check from point 6R on the board to 3R and 4R. The resistance of each half of the motor control winding through these paths should be 2.3 ohms.

l. To verify that the motor is good, place 3 to 10 volts rms across its control winding from any available auxiliary transformer.

NOTE

This should not be an autotransformer. It should be a transformer with an isolated secondary.

m. Shunt the voltage from the auxiliary transformer across the motor with the recorder switch on. This can be done by touching the metal paths in the red connector at locations 3 and 4 with small probes across which the voltage is impressed.

n. Check that the motor drives the pen to one side of the scale. Reverse the probes to drive the motor in the opposite direction.

o. If these checks have not revealed the location of trouble, the amplifier board must be serviced or replaced.

NOTE

It is conceivable but unlikely that both power transistors could be faulty or have open connections to them through the blue connector. If one is faulty, the symptom described in Paragraph 5.1.4 is produced.

5.2.3 Recorder Does Not Follow Signal

If the input circuit is open, the recorder will not follow a signal but the motor will develop opposing torque when the motor pulley is turned quickly. To check an open input circuit:

a. Check that the input cable connections are on pins 1, 2, and 4 under the input cover and that the connections in the input connection box inside the rear cover are good.

b. Make an ohmmeter check from the positive input inside the input connection box to the red lead of the input cable which goes to pin 2, and also from the negative input to the black lead which goes to pin 1.

5.2.4 Recorder Follows Signal, But Motor Hums and Pen May Vibrate

If the recorder follows the signal properly, but the motor hums and pen vibrates at 60 cps:

a. Refer to the treatment of electrical interference in Section 2, Paragraph 2.2.4 as excessive power frequency interference getting into the input is one possible cause for this condition.

b. If these connections are good, check for open connections to input shields, reference power supply, and slidewire coming to the input board.

c. Check that the input has not shorted to ground within the recorder.

NOTE

If the input and guard have not been deliberately grounded at the input terminals, resistance should be 10,000 megohms from guard and input to ground.

d. Check for open circuit in each half of the center-tapped motor control winding and in the push-pull output stage.

e. Check the connections to the power transistors and the motor.

f. Check each power transistor. If these are good, the trouble probably is on the amplifier board.

5.2.5 Pen Does Not Stand Still With Constant Input Signal

a. Turn down the gain if the pen oscillates at a fairly constant frequency of about 30 cps.

b. Replace the slidewire if the pen response is noisy. This is indicated if the pen jitters randomly at particular points on the chart but not at others. In some cases, when the effect is slight, the gain may be reduced enough to stop the jitter while maintaining an adequately narrow dead zone.

c. Check that the slider arm has not become loose on the slidewire. This is indicated if the pen oscillates at a fairly low frequency and amplitude. If the motor pulley is turned by hand, the point of balance changes when the pulley is turned far enough.

d. Check for electrical interference (Paragraph 2.2.4), indicated by spikes on the record due to switching transients on the power line feeding into the recorder.

NOTE

If transverse ac stray pickup is being switched on and off to the input of the recorder, it follows from the theory of ac transients that the same filter which successfully rejects the ac stray in the steady state case inevitably generates a dc transient when the stray is turned on or off. This dc transient is maximum if the ac is applied when the ac signal is passing through zero.

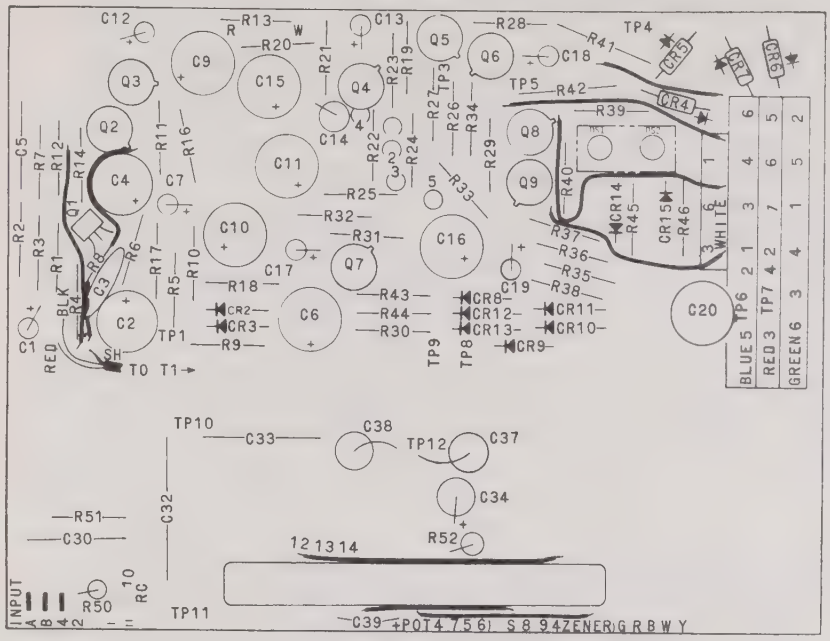
5.3 SERVICING THE AMPLIFIER AND INPUT BOARD (Figure 5-2 and Table 5-1)

CAUTION

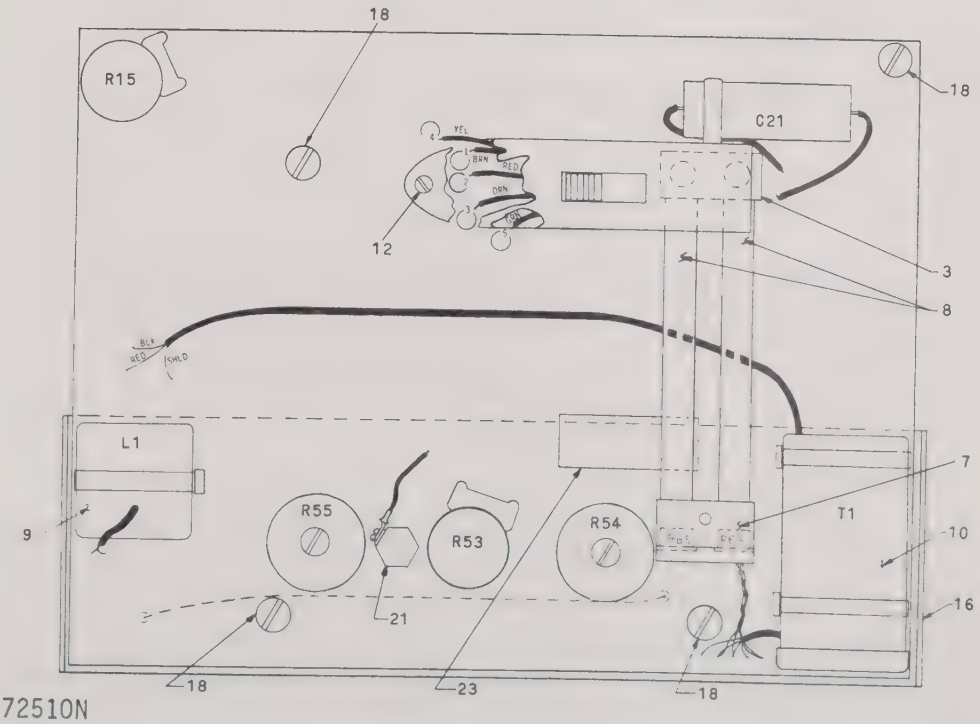
Amplifier and input board servicing should be undertaken only by a skilled electronic technician with the proper equipment. Care should be taken that voltage potential, which would cause damage to the circuit, is not present on the soldering iron. Excessive heat may cause conductor pads to raise from the circuit board.

If a suction-type solder remover is available, use it to remove excess solder from any pad to be worked on. Try to straighten or cut off component leads from the conductor side, before pulling them through the board.

Open the holes by pushing a scribe or other pointed instrument through from the conductor side before attempting to push new components through from the component side. An almost sure way to raise the conductor patterns from the board is to heat the conductor pattern and try to push a component lead through a solder blocked hole from the component side.



C175151C
3-5-68
TP35



C172510N
1-3-68

Figure 5-2. Location of Components

TABLE 5-1

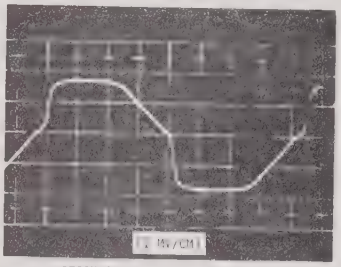
DC VOLTAGES WITH SMALL ERROR, GAIN POTENTIOMETER COUNTERCLOCKWISE

Component	Test Point	Reading
Base voltage Q1	Right side R1 to ground	1.8 volts
Emitter voltage Q1	Left side R6 to ground	2.9 volts
Emitter voltage Q2	Left side R11 to ground	2 volts
Base voltage Q3	Right side R11 to ground	10 volts
Emitter voltage Q3	Right side R16 to ground	10.2 volts
Collector voltage Q3	Right side R14 to ground	6 volts
Power supply first three stages	Right side R17 to ground	18 volts
Voltage across zeners	Top CR2 to ground	22 volts
First filter capacitor	9 to ground	40 volts
Power supply second three stages	Bottom R18 to ground	18 volts
Base voltage Q4	Top R20 to ground	11.5 volts
Emitter voltage Q4	Right side to ground R23	11.6 volts
Collector voltage Q4	Right side R22	5.8 volts
Emitter Q5, base Q6	Test point 3 to ground	5.9 volts
Base voltage Q7	Top R30	5.4 volts
Collector Q6	Top R28	3 volts
Collector Q7	Left R29	2.9 volts
Base Q8 or Q9	Top R37, R38	0.15 - 0.35 volt
Base Q10, Q11 (output)	Right R40, Top R39	0.2 - 0.35 volt
Emitter Q10, Q11 (output)	Top R41, R42	0.15 - 0.35 volt
Output stage power supply	Lead of CR4 or CR5	-8.5 volts

NOTE

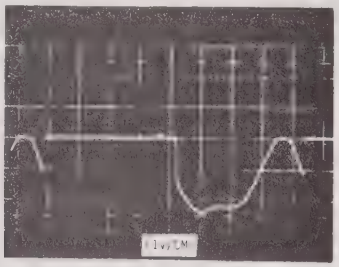
Base connection on transistor type 2N1302 through 2N1309 and collector connection on transistor type 2N456A are on the case.

ALL MEASUREMENTS MADE WITH RECORDER IN STANDBY, INPUT SHORTED AND PEN DISPLACED FROM ZERO TO PRODUCE SPECIFIED ERROR SIGNAL.
RECORDER SPAN - 10 MV.



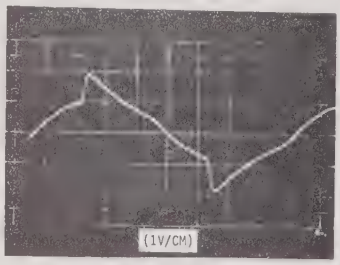
SECONDARY OF INPUT TRANSFORMER

4 MV ERROR SIGNAL AMPLITUDE INCREASES WITH ERROR. MEASURE BETWEEN EYELET BELOW AND TO LEFT OF C1 AND GROUND.



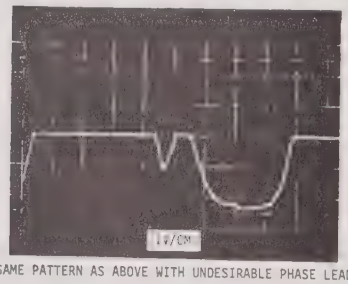
TEST POINT 5 TO GROUND

SATURATING SIGNAL (TEST POINT 4 SIMILAR BUT WITH PHASE REVERSAL).

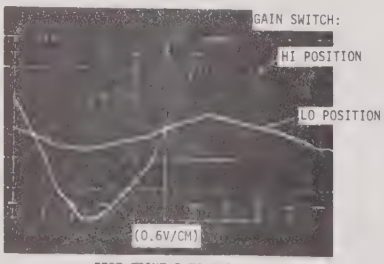


VOLTAGE ACROSS GAIN POT

4 MV ERROR SIGNAL. AMPLITUDE INCREASES WITH ERROR. TEST POINT 2 TO GROUND.

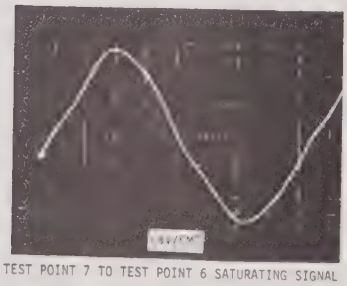


SAME PATTERN AS ABOVE WITH UNDESIRABLE PHASE LEAD.



TEST POINT 3 TO GROUND

200 μV ERROR SIGNAL. AMPLITUDE VARIES WITH GAIN SETTING.

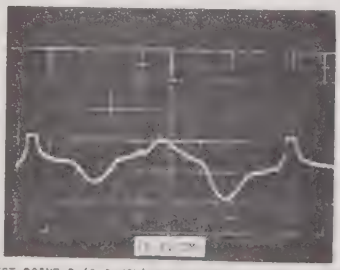


TEST POINT 7 TO TEST POINT 6 SATURATING SIGNAL

CAUTION

BE SURE LOW SIDE OF OSCILLOSCOPE IS NOT GROUNDED THROUGH THIRD WIRE IN LINE CORD OR OTHERWISE BEFORE CONNECTING IT TO TP6 OR TP7.

UNDER ACTUAL SIGNAL CONDITIONS UP TO ABOUT 10 TO 15 VOLTS PEAK-TO-PEAK OF QUADRATURE AND HARMONIC STRAY MAY EXIST AT BALANCE AND DOES NOT NORMALLY CAUSE IMPAIRMENT OF PERFORMANCE.



TEST POINT 5 (0.2V/CM) ZERO ERROR QUADRATURE STRAY

(ALL PATTERNS 2 MSEC/CM TIME BASE)

TP47

Figure 5-3. Amplifier Oscilloscope Patterns

The circuit details of the amplifier are shown in the schematic. Locations and identifications of the components and also the conductor pattern of the circuit board are shown in Figure 5-2.

Table 5-1 indicates normal dc voltage at various points in the circuit. In Table 5-1 reference is made to right, left, top, and bottom of certain resistors or diodes on the board. These components have bare leads which can be touched with test probes. The view of the board is from the bottom end, where the four 6-point connectors are attached. Oscilloscope waveforms are shown in Figure 5-3.

On the input side of the board—with the zener reference power supply, the function, span, and zero cards in place, and the feedback slidewire connected—the zener reference power supply voltage at pins 8 and 9 should be 12 volts. The feedback slidewire voltage between pins 5 and 6 should be 1.6 volts.

If facilities for precise readings are used, the nominal change in the slidewire voltage as the pen is moved from left edge of the chart grid to the right edge of the chart grid is 1381 millivolts. The voltage across each end resistance of the slidewire is approximately 119 millivolts for Texas Instruments slidewires. For Beckman potentiometers which are used in some recorders, the end resistance is smaller.

5.3.1 Selected Components

There are several components in the amplifier which are selected. The selection factors are listed in Table 5-2.

TABLE 5-2

SELECTED COMPONENTS

Item	Description	Qty
Q1	Selected for low noise and high gain at 70°C	1
Q4	2N1305; $h_{ie} > 24,000$ ohms $I_E = 0.33$ ma. $1 + h_{FE} > 100$	1
Q8 and Q9	2N1308; $h_{FE(SAT)} > 110$ V_{CE} 0.5v	2

5.3.2 Reference Voltage Unit

Table 5-3 is a voltage chart for 120-volt ac line voltage on the primary of T2 and a 200-ohm, 2-watt load resistor across the output leads (RED-BLACK).

TABLE 5-3

VOLTAGE CHART

Test Instructions	Normal Indication	Probable Cause of Abnormal Indication
Transformer T1 primary	0.75 ± 0.1 vac	Faulty power transformer T2
Transformer T2 secondary	25 ± 5 vac	Faulty T1
Red-black leads (output)	12 ± 0.03 vdc	Faulty reference voltage unit
C2	26 ± 6 vdc	Faulty rectifier CR1 to CR4
C2	1.5 ± 0.5 v p-p	C2 open
CR8	9 ± 0.5 vdc	CR8 faulty; R5 open
Q4 base to (–) black	9 ± 0.5 vdc	Resistors R4, R7, R8, or R9 open
Q2 base to (–) black	13.4 ± 0.4 vdc	CR5, CR6, or CR7 faulty Resistors R4, R3 open Capacitor C3 shorted Q4, Q1, or Q2 faulty
Q1 collector to emitter	8 ± 0.4 vdc	Q1 faulty; R2 open
Red-black leads (output)	2 ± 1 mv p-p	RG open
Red-black leads (output)	No high frequency oscillation	C3 open
CR7 to (–) black	18 ± 2 vdc	CR5, CR6, or CR7 faulty R1 open
Q3 emitter to (–) black	8.5 ± 0.5 vdc	R6 open

5.4 CHART CARRIAGE (Figures 5-4 and 5-5)

CAUTION

Do not oil the cork clutch washer on the chart drive sprocket.

The chart carriage assembly is designed for easy maintenance. The usual service requirements are to keep the carriage clean and lubricate all bearings with lightweight machine oil. Relubrication at yearly intervals is sufficient for normal usage.

Three mechanisms of the chart carriage are adjustable for correct chart tension. The takeup torque clutch, on the left side of the recorder, is provided by chain tension against the white nylon wheel. The chain tension is adjusted by loosening the screw retaining the spring tab and rotating the tab clockwise to increase or counterclockwise to decrease the tension. The correct setting can be determined by wrapping a string around an empty takeup spool and adjusting until the string tension is 4-1/2 ± 1/2 ounces.

The supply roll brake finger should be adjusted to a torque of 11-1/2 ± 1 oz/in. Loosen the setscrew of the hexagonal collar and rotate the collar to make the adjustment.

The chart sprocket brake should be adjusted so that a tension of 8 ± 2 ounces is required to unwrap a string wrapped on the polished diameter. To make this test, the black drive chain must first be removed by pulling back the spring-loaded idler sprocket. This sprocket is retained on its stub shaft only by the chain. To change the brake setting, the flat spring on the righthand end is adjusted by its screw.

5.4.1 Removal of Chart Drive Sprocket

To remove the chart drive sprocket from the carriage:

a. Remove the flat tension spring from the right side of the chart carriage.

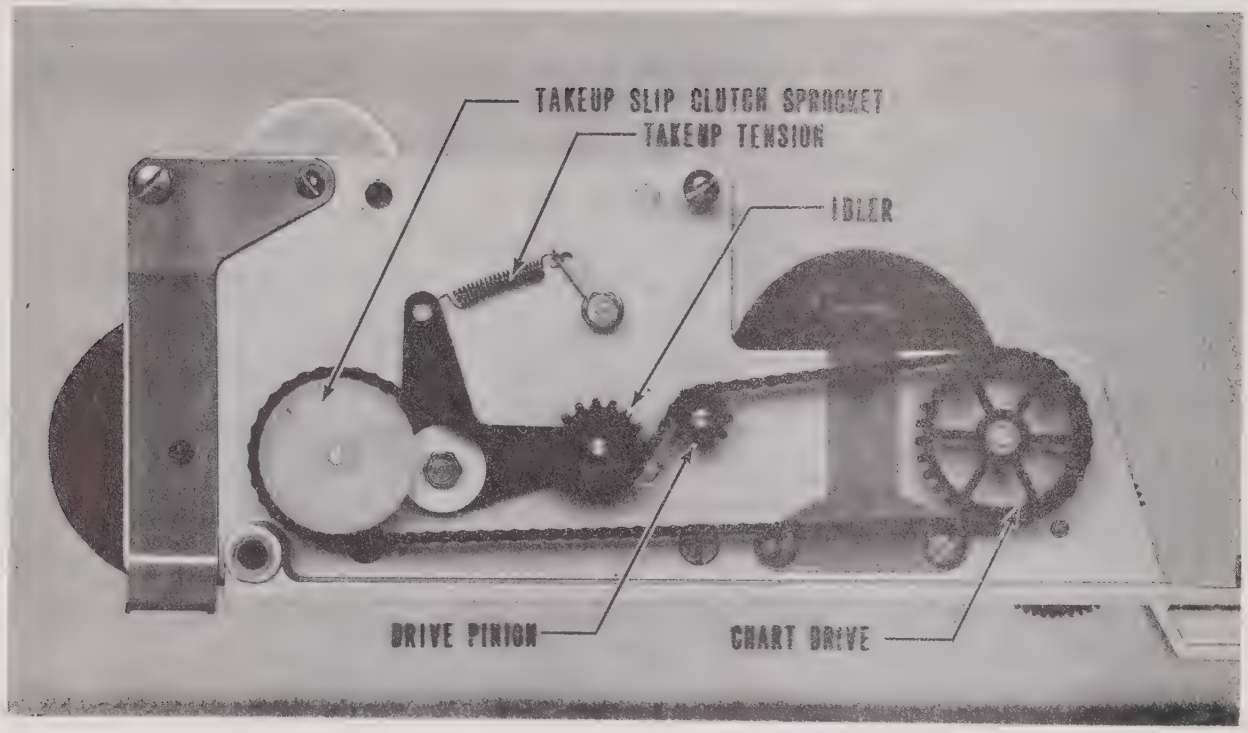
b. Pull out the pointed shaft that the spring was bearing against. A pair of pliers is normally required for this.

c. Tilt the right end of the sprocket assembly up until it clears the carriage and pull the assembly away to the right side of the carriage.

d. The cork washer, gear and felt washer are loose on the assembly. Note the order of parts so correct reassembly can be made.

5.4.2 Shortening Drive Chain

It is possible for the drive chain to stretch until the spring-loaded idler touches the chain opposite it. To remove a link from the chain, first pull the idler back and slip the chain off of all the wheels. Open up the chain



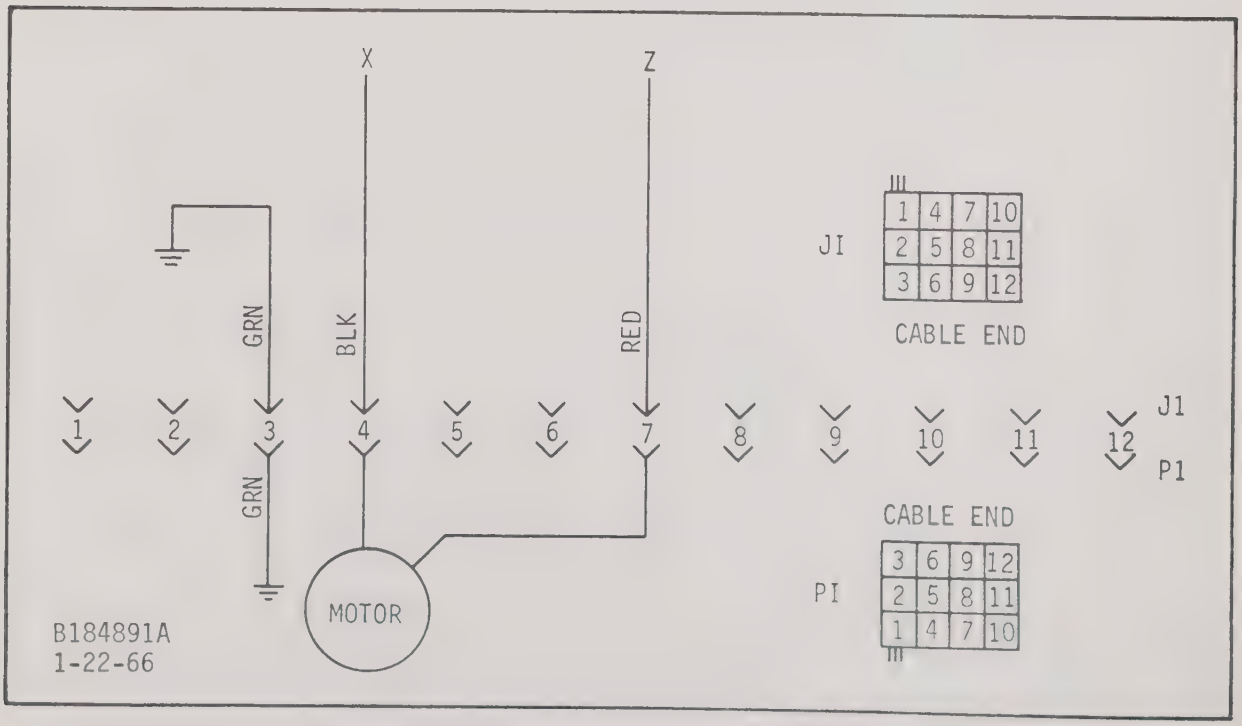


Figure 5-5. Schematic, Basic Chart Drive

by spreading any link with a thumbnail. Remove one link, reassemble, and readjust the takeup tension as previously described.

5.4.3 Chart Carriage Drive Chain Cleaning

Refer to Figure 5-4, chain drive side of the chart carriage.

To remove the chain from the carriage, rotate the idler assembly away from the chain, remove the idler sprocket from its shaft, and remove the chain.

The chain should be cleaned with a nonabrasive detergent or cleaning fluid.

CAUTION

Do not use chlorinated solvent.

Thoroughly dry the chain, preferably by blowing it off with air.

Saturate a piece of cloth or felt with light machine oil and rub the chain thoroughly. Wipe off the excess.

Brush or wipe off the sprocket teeth and the surface of the white nylon pulley where the chain rides. Use a soft cloth or tissue; do not scrape.

Add a drop of oil to the idler sprocket shaft, and between the idler arm and washer.

Replace the idler sprocket and route the chain as shown in Figure 5-4 while holding the idler assembly clear.

Engage the idler assembly and check for proper seating of the chain on the white nylon pulley. Reset takeup torque per Paragraph 5.4 if necessary.

5.4.4 Chart Carriage Lubrication Points

A check list of lubrication points for the chart carriage follows.

Drive sprocket axle on the left side

Bearing and drive sprocket axle on the right side

Bearings on each end of the long 1/8-inch-diameter shaft

Idler sprocket shaft and idler arm pivot boss

Drive sprocket pinion bearing

Takeup gear bearing

Between the supply roll finger and its shaft

5.5 PEN DRIVE ASSEMBLY

5.5.1 Pointer Removal

To remove the pointers, remove the two 4-40 screws on top of the pen carriage.

To replace, position the pen on a grid line and set the pointer to the corresponding mark on the scale. Carefully adjust the pointer so that it will not drag on the scale or interfere with other pointers.

5.5.2 Pen Carriage Removal

To remove a pen carriage:

a. Remove the pen and inkwell assembly.

b. Loosen the cable clamping screw on the back side of the pen carriage.

c. Remove the four 6-32 screws (Figure 5-6) and swing the pen drive assembly high enough to expose the ends of the rods.

d. Press the rods out from left to right.

e. To replace the pen carriage, reverse procedures a. through d.

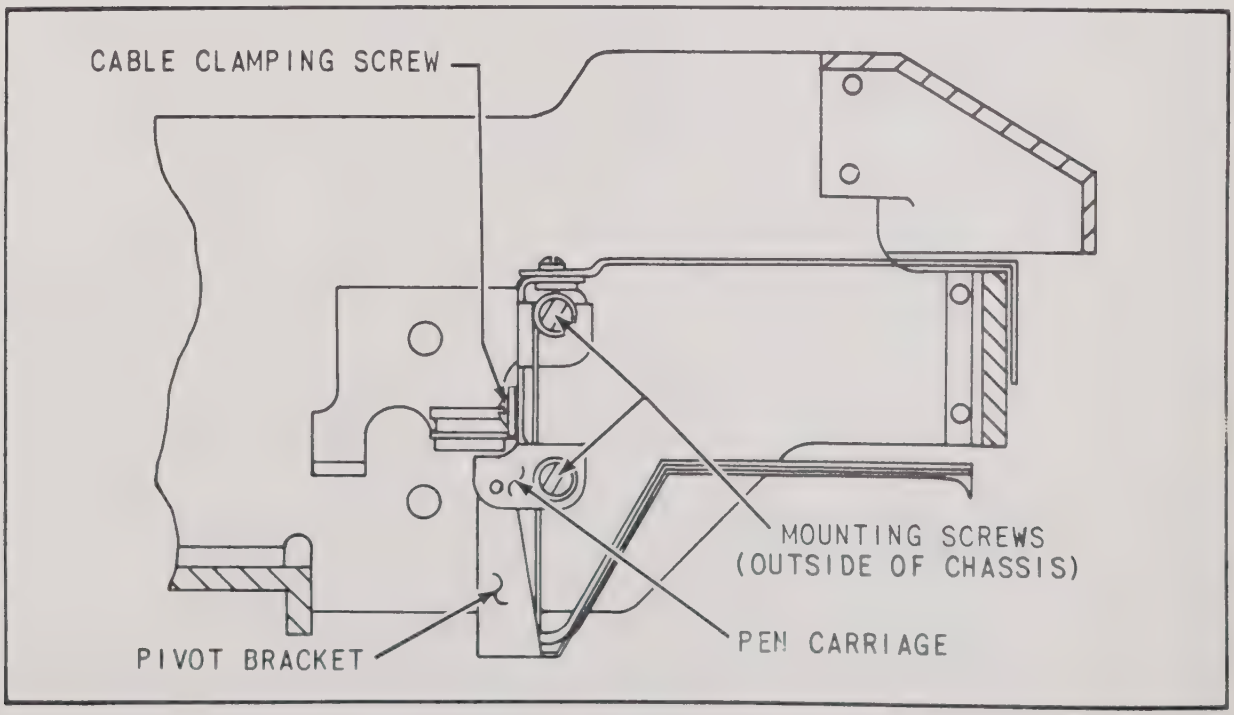


Figure 5-6. Pen Carriage Removal

Rotate the slidewire pulley against the stop and position the pen about 1% of the grid width outside of the extreme chart grid line. Place the cable under the cable clamp and tighten screw.

Clean and oil the rods with light machine oil. (An appendix describes the removal of the pen carriage pen lifter.)

5.5.3 Motor Pulley Assembly Removal

Remove the pen drive cable (Figure 5-7, Cabling Instructions). Loosen the two 4-40 setscrews at the bottom of the pulley assembly and slide the assembly from the motor shaft. Reverse the procedure to replace. Position the assembly on the motor shaft vertically so that the center of the threaded portion of the pulley is at the same level as the center of the corresponding slidewire pulley. Replace the pen drive cable.

5.5.4 Servomotor Removal

Unplug the motor. Remove the motor pulley assembly (Paragraph 5. 3). Remove the four 8-32 screws from the motor (located on the top side of the pen drive plate) and remove the motor. Reverse the procedure to replace.

5.5.5 Slidewire Removal

To remove the slidewire:

a. Remove any accessories attached to the slidewire shaft.

b. Loosen the screws holding the pen drive cable and remove the cable from the slidewire pulley.

c. Remove the slidewire pulley. This is done by loosening the locknut and sliding the pulley off the shaft.

d. Remove the cover from the input unit and disconnect the slidewire cable.

e. Loosen the three slidewire mounting screws and remove the slidewire assembly.

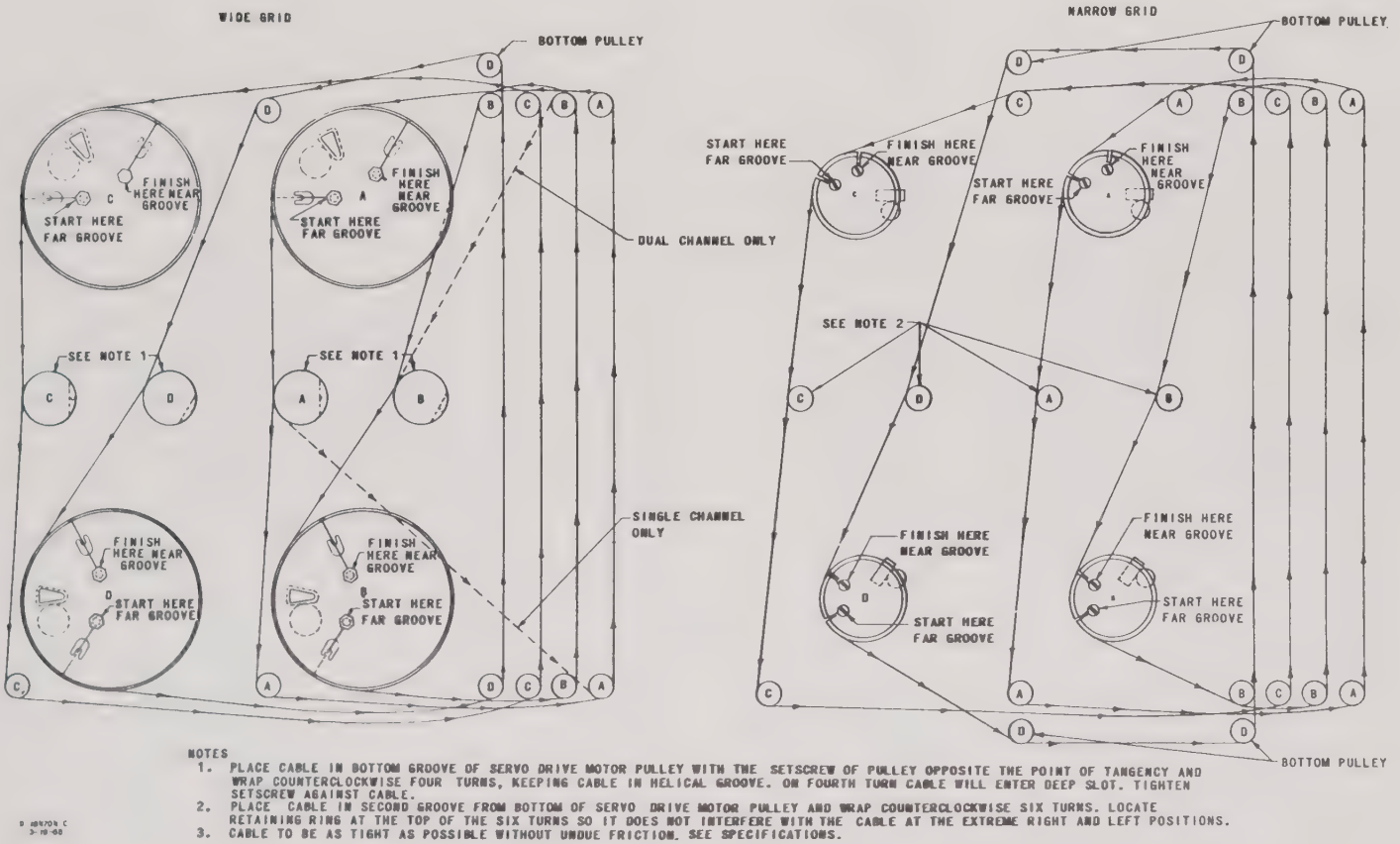
To replace the assembly, reverse steps a. through e., referring to Figure 5-7 to recable. Rotate the slidewire pulley fully counterclockwise against the stops and the slidewire shaft fully counterclockwise against its stop. Tighten the shaft locknut.

5.6 CLEANING INK PENS

To clean an ink pen:

a. Open the chart carriage.

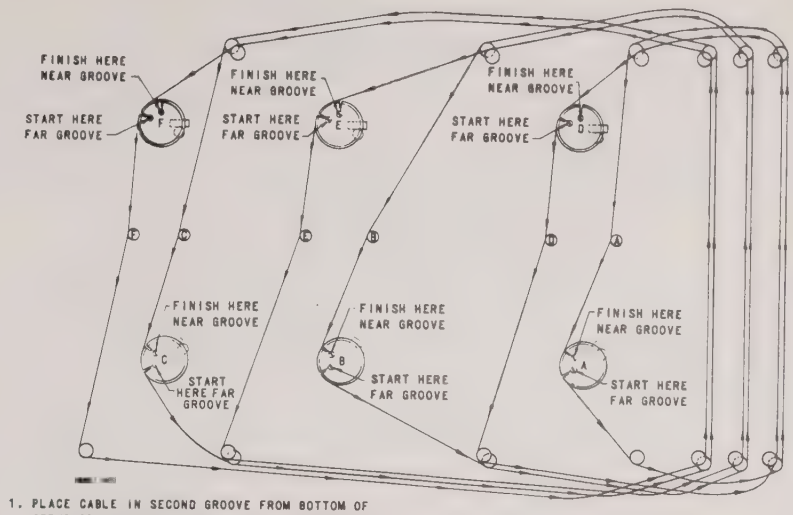
b. Pinch together the tabs holding the inkwell assembly in the inkwell carriage and lower and remove the assembly.



NOTES

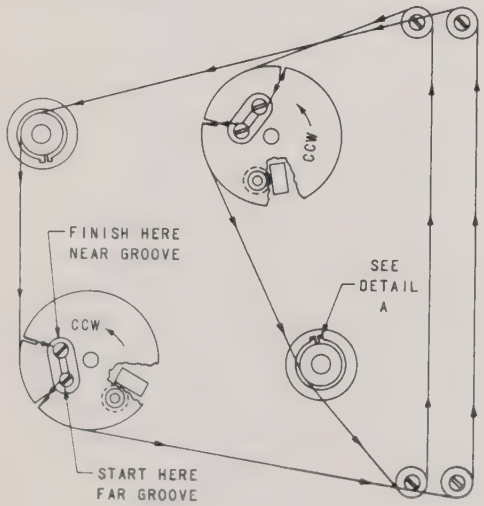
1. PLACE CABLE IN BOTTOM GROOVE OF SERVO DRIVE MOTOR PULLEY WITH THE SETSCREW OF PULLEY OPPOSITE THE POINT OF TANGENCY AND WRAP COUNTERCLOCKWISE FOUR TURNS, KEEPING CABLE IN HELICAL GROOVE. ON FOURTH TURN CABLE WILL ENTER DEEP SLOT. TIGHTEN SETSCREW AGAINST CABLE.
2. PLACE CABLE IN SECOND GROOVE FROM BOTTOM OF SERVO DRIVE MOTOR PULLEY AND WRAP COUNTERCLOCKWISE SIX TURNS. LOCATE RETAINING RING AT THE TOP OF THE SIX TURNS SO IT DOES NOT INTERFERE WITH THE CABLE AT THE EXTREME RIGHT AND LEFT POSITIONS.
3. CABLE TO BE AS TIGHT AS POSSIBLE WITHOUT UNDUE FRICTION. SEE SPECIFICATIONS.

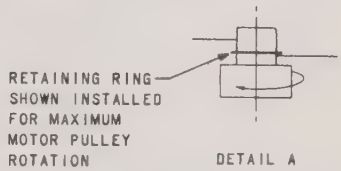
Figure 5-7. Cabling Instructions (Sheet 1 of 3: Wide-Carriage Recorder, One and Two Channel)



1. PLACE CABLE IN SECOND GROOVE FROM BOTTOM OF SERVO DRIVE MOTOR PULLEY. WRAP COUNTERCLOCKWISE 4 TURNS. LOCATE RETAINING RING AT CENTER OF THE 6 TURNS SO THAT IT DOES NOT INTERFERE WITH THE CABLE AT THE EXTREME RIGHT AND LEFT POSITIONS.
2. CABLE TO BE AS TIGHT AS POSSIBLE WITHOUT UNDUE FRICTION. (SEE SPECIFICATIONS NO. A184755)

Figure 5-7. Cabling Instructions (Sheet 2 of 3: Wide-Carriage Recorder, Multichannel)





CABLING INSTRUCTIONS:

1. BEFORE CABLING, CARRIAGE ASSEMBLY MUST BE FREE TO SLIDE DOWN RODS IN BOTH DIRECTIONS BY ITS OWN WEIGHT WITHOUT CHATTER.
2. TURN POTENTIOMETER PULLEY ALL THE WAY COUNTERCLOCKWISE AND START CABLE IN LOWER PULLEY GROOVE.
3. WRAP FIVE TURNS, STARTING TWO GROOVES FROM BOTTOM OF MOTOR PULLEY.
4. MAKE ONE TURN AROUND UPPER POTENTIOMETER PULLEY GROOVE AND FINISH AS SHOWN.
5. TURN MOTOR PULLEY SO THAT POTENTIOMETER IS NOW ALL THE WAY CLOCKWISE AND RETIGHTEN CABLE AT FINISH POINT TO WHERE A 1-OZ WEIGHT HUNG ON CABLE AT A POINT NEAR THE CENTER OF THE DISTANCE BETWEEN THE PULLEY BEARINGS WILL DROP 1/16 (+1/32) (-0) INCH.
6. INSTALL RETAINING RING AS SHOWN IN DETAIL A.

188240K
1-6-67

Figure 5-7. Cabling Instructions (Sheet 3 of 3: Narrow-Carriage Recorder)

c. Clean the pen with a primer syringe filled with clean water. Use 0.006-inch-diameter steel wire to dislodge foreign matter in the pen if necessary. If particles are too large to be forced through the tip, force clean water through the tip end of the pen and clean out the reservoir.

CAUTION

Do not use copper, lead, or other soft or brittle wire.

d. Replace the pen assembly in the carriage, with the long upright tab against the slide rods.

APPENDIX A

SPECIFICATIONS

Recorder weights are listed in Table A-1; electrical specifications are listed in Table A-2, and dimensions are shown on Figure 2-2.

TABLE A-1

WEIGHTS OF RECORDERS

Recorder	Weight (pounds)	Weight (kilograms)
Portable recorders		
1-channel, 4-1/2" grid	23	10.4
1-channel, 9-3/4" grid	26	11.8
2-channel, 9-3/4" grid	33	15.0
Wide-carriage flushmount recorders		
1-channel	48	22
2-channel	55	25
3-channel	65	30
4-channel	72	33
5-channel	94	43
6-channel	101	50
Narrow-carriage flushmount recorders		
1-channel	39	18
2-channel	55	25

TABLE A-2

ELECTRICAL SPECIFICATIONS

Item	Description
Line voltage	120 ± 10% volts at 60 ± 5% ~ or 115 or 230 volts at 50 ± 5% ~
Volt-amperes per function Example – Two-channel with standard chart drive and lighting kit 24 + 24 + 3 + 14 = 65 volt-amperes Example – Two-channel portable recorder with standard chart drive (no lighting kit): 24 + 24 + 3 = 51 volt-amperes	24 maximum per servo channel 3 for standard chart drive up to 4 in./min 8.5 for high speed chart drives about 4 in./min 16 maximum for transmission chart drive 14 lighting kit (flushmount models) NOTE For jump speed combinations on flush-mount models, add volt-amperes of HI and/or LO speed chart drives.
Accuracy	± 0.25% of full scale or ± 5 microvolts, whichever is greater
Linearity	± 0.1% of full scale
Deadband	0.1% of full scale
External circuit resistance rating	25,000 ohms when attenuator not used or in xl attenuator position
Span	Standard available 1, 5, 10, 50, 100 millivolts
Zero	Standard zero left, center, and right with screwdriver adjustability of ± 3%
Attenuator input resistance Example: x20 position is 10,000 x 20 or 200,000 ohms input resistance	10,000 ohms times attenuation number up to a maximum of 1 megohm. Note potentiometric input on xl position.
Input circuit	Floating and guarded transformer type
Guard to ground voltage	Rating 500 volts maximum
Interference rejection	AC transverse 60 db at line frequency AC longitudinal 100 db at line frequency DC common mode 100 db
Reference supply	Zener diode regulated with long term stability of 0.1%
Pen speeds	Standard 0.4, 1, 5, 10, or 24 seconds for full-scale step signal
Basic servo controls	
Gain	HI/LO switch with screwdriver adjustment
Calibrate control	Screwdriver adjustment
Damping control	Screwdriver adjustment
Zero control	Screwdriver adjustment
Power control	OFF, IN/HR, STANDBY, IN/MIN

FIELD SERVICE OFFICES

INDUSTRIAL PRODUCTS DIVISION

ALABAMA
TEXAS INSTRUMENTS INCORPORATED
3313 MEMORIAL PARKWAY, S.W.
HUNTSVILLE, ALABAMA 35801
205 881 4061

ARIZONA
TEXAS INSTRUMENTS INCORPORATED
2535 CAMEL BACK ROAD
PHOENIX, ARIZONA 85022
602 279 5531

CALIFORNIA
TEXAS INSTRUMENTS INCORPORATED
5005 W. CENTURY BLVD.
INGLEWOOD, CALIFORNIA 90304
213 673 0845

TEXAS INSTRUMENTS INCORPORATED
230 CALIFORNIA AVENUE, SUITE 201
PALO ALTO, CALIFORNIA 94306
415 326 6770

PACIFIC ELECTRICAL INSTRUMENT LABS
111 MAIN STREET
SAN FRANCISCO, CALIFORNIA 94105
415 421 7185

FLORIDA
LEE ASSOCIATES
200 E. MARKS STREET
ORLANDO, FLORIDA 32803
305 241 4445

ILLINOIS
TEXAS INSTRUMENTS INCORPORATED
7135 N. BERRY AVENUE
DES PLAINES, ILLINOIS 60018
312 297 2910

MASSACHUSETTS
TEXAS INSTRUMENTS INCORPORATED
480 NEPONSET STREET
CANTON, MASSACHUSETTS 02021
617 828 5024

MICHIGAN
S. STERLING COMPANY
21250 10½ MILE ROAD
SOUTHFIELD, MICHIGAN 48075
313 357 3700

MINNESOTA
TEXAS INSTRUMENTS INCORPORATED
7615 METRO BLVD.
MINNEAPOLIS, MINNESOTA 55424
612 941 3166

INSTRUMENT SERVICE INCORPORATED
917 PLYMOUTH ROAD, NORTH
MINNEAPOLIS, MINNESOTA 55411
612 521 8803

MISSOURI
SCHERRER INSTRUMENTS
5449 DELMAR BLVD.
ST. LOUIS, MISSOURI 63112
314 367 9800

NEW JERSEY
TEXAS INSTRUMENTS INCORPORATED
301 CENTRAL AVENUE
CLARK, NEW JERSEY 07065
201 382 9800

OHIO
S. STERLING COMPANY
5827 MAYFIELD ROAD
CLEVELAND, OHIO
216 442 8080

PENNSYLVANIA
IMPAC INSTRUMENTS SERVICE
201 EAST CARSON STREET
PITTSBURGH, PENNSYLVANIA 15219
412 381 4655

TEXAS INSTRUMENTS INCORPORATED
1013 BARCLAY BLDG.
ONE BELMONT AVENUE
BALA CYNWYD, PENNSYLVANIA 19004
215 839 6380

TEXAS
TEXAS INSTRUMENTS INCORPORATED
13500 N. CENTRAL EXPRESSWAY
SOUTH BUILDING
DALLAS, TEXAS 75222
214 238 3881

TEXAS INSTRUMENTS INCORPORATED
12201 SOUTHWEST FREEWAY
P. O. BOX 66027
HOUSTON, TEXAS 77006
713 227 3611

VIRGINIA
TEXAS INSTRUMENTS INCORPORATED
7712 OLD SPRINGHOUSE ROAD
McLEAN, VIRGINIA 22101
703 893 5550

WASHINGTON
DEL-TECH INSTRUMENTS INCORPORATED
19265 DES MOINES WAY SOUTH
SEATTLE, WASHINGTON 98148

INTERNATIONAL

CANADA
INSTRONICS TECHNO-PRODUCTS LTD.
11 SPRUCE STREET
STITTSVILLE, ONTARIO, CANADA
613 836 4411

ENGLAND
TEXAS INSTRUMENTS LIMITED
DALLAS ROAD
BEDFORD, ENGLAND
58701

FRANCE
TEXAS INSTRUMENTS FRANCE
06 VILLENEUVE-LOUBET, FRANCE
736 36 56

GERMANY
TEXAS INSTRUMENTS DEUTSCHLAND GMBH
IM KAISEMER 5
7 STUTTGART, GERMANY
22 53 95

INDUSTRIAL
PRODUCTS
DIVISION

TEXAS INSTRUMENTS
INCORPORATED

P. O. BOX 66027 HOUSTON, TEXAS 77006

August 8, 1968

servo/riter® II RECORDER

PLEASE READ BEFORE PACKING RECORDER FOR SHIPMENT

Drain ink and flush inking system with water. Repackage in original packing. If original packing is not available:

1. Wrap recorder in heavy paper to protect finish.
2. Place recorder in tight fitting corrugated fibre board box.
3. Place this assembly into a second corrugated fibre board box large enough to provide at least 3 inches of resilient cushioning material on all sides of the inner box. The preferable material is rubberized horse hair pads. Excelsior should not be used since it tends to settle, leaving parts of the unit unprotected.

If, for any reason, this instrument must be returned to Texas Instruments for service, please check the below listed items which best describe the nature of your problem. Additional space is provided under "Remarks" for any further information you might wish to add. This information will enable our service department to give the most efficient service.

This completed repair form should be placed inside the unit to be returned, before it is packed for shipment.

MODEL _____ SERIAL NO. _____

☐ Servoamplifier

☐ Servo, Mechanical

☐ Chart Carriage

☐ Chart Drive or Transmission

☐ Chart Takeup

☐ Inking System or Pens

☐ Calibration

ACCESSORIES

☐ Marker Pens

☐ Control Devices

☐ Other

REPAIR REQUIREMENTS

☐ General Overhaul

☐ Repair as Required

REMARKS _____

_____

_____

NAME _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

PHONE: AREA CODE _____ NUMBER _____

www.manualsplus.com
1033937